

CHAPTER ONE

INTRODUCTION

1.1 Introduction:–

Lean Six Sigma is simply a process for solving a problem of low productivity in Sudanese industry. It consists of five basic phases: Define, Measure, Analyze, Improve, and Control. This process is also known as DMAIC (pronounced “duh–may–ik”), its acronym.

DMAIC (Lean Six Sigma) is also a system of management that results in a steady pipeline of projects that are ready for improvement. There are obstacles to smooth operations in any business, and Lean Six Sigma provides guidelines to help you select the right projects at the right time. Once projects are selected, you and your improvement team(s) can use DMAIC to further refine the projects and deliver quantifiable, sustainable results.

Lean Six Sigma is a methodology that relies on a collaborative team effort to improve performance by systematically removing waste;

combining lean manufacturing / lean enterprising and six sigma to eliminate the eight kinds of waste(Muda): Time, Inventory, Motion, Waiting, Over production, Over processing, Defects, and Skills abbreviated as 'TIMWOODS').

The Lean Six Sigma concepts were first published in a book titled *Lean Six Sigma: Combining Six Sigma with Lean Speed* by Michael George and Robert Lawrence Jr. in 2002. Lean Six Sigma utilizes the DMAIC phases similar to that of Six Sigma. Lean Six Sigma projects comprise aspects of Lean's waste elimination and the Six Sigma focus on reducing defects, based on critical to quality (CTQ) characteristics

The DMAIC toolkit of Lean Six Sigma comprises all the Lean and Six Sigma tools. The training for Lean Six Sigma is provided through the belt based training system similar to that of Six Sigma. The belt personnel are designated as white belts, yellow belts, green belts, black belts and master black belts

For each of these belt levels skill sets are available that describe which of the overall Lean Six Sigma tools are expected to be part at a certain Belt level. These skill sets provide a detailed description of the

learning elements that a participant will have acquired after completing a training program. The level upon which these learning elements may be applied is also described. The skill sets reflects elements from Six Sigma, Lean and other process improvement methods like the theory of constraints (TOC) total productive maintenance (TPM).

1.2 Problem statement:–

low production by 20% of planned production of the bullet case in
Alshegara factory

1.3 Objectives:–

To identify source of waste in Alshegara factory with the objective of improving productivity and propose solution by using lean six sigma method.

1.4 SCOPE OF PROJECT

The scope of the project is to use lean six sigma concepts to improve Production of the bullet case caliber 7.6*54mm

1.5 Expected result:–

Implementing lean Six Sigma will deliver value to organization by improving productivity.

1.6 Constraints of study:–

- The most significant challenge is to change people and their mindsets
- It is not unusual to take more than two years to make the changes required just to implement lean. Implementing both lean and Six Sigma together means even greater complexity.

CHAPTER TWO

Literature review

2-1 Literature review:

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.[1]

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 'measure-analyze-improve-control' (MAIC) and added to

‘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]

in 2010 Ronald D.Snee make paper to assess Lean Six Sigma to identify important advances over the last ten to 15 years and discuss emerging trends that suggest how the methodology needs to evolve. The goal is to aid those who want to use the method to improve performance as well as assist those developing improvement methodologies.

The use and development of Lean Six Sigma is reviewed including the origins of the method, the what, why and benefits of the method,

how the approach is different, the integration of Lean and Six Sigma, implementation mistakes made, lessons learned and developments needed in the future.

It is found that organizations have many different improvement needs that require the objectives and methods contained in the lean and Six Sigma methodologies. It is also found that deployment and sustaining improvements are major issues that can be overcome by building a sustaining infrastructure and making improvement a business process. Critical issues include using Lean Six Sigma to generate cash in difficult economic times, development of data-based process management systems and the use of working on improvement as a leadership development tool.

These findings suggest that improvement is most effective when approached in an holistic manner addressing improvement in all parts of the organization using a holistic improvement methodology such as Lean Six Sigma. Improvement must address the flow of information and materials through processes as well as the enhancement of value-adding process steps that create the product for the customer. This leads naturally to making improvement a business process that is

planned for, operated and reviewed as any other important business process is

The roadmaps, guiding principles, and deployment pitfalls identified will be of value to those initiating and operating improvement processes in their organizations enabling them to rapidly create useful and sustainable improvements. The discussion of needed enhancements will be of value to those who are working to improve the effectiveness of the approach.[3]

oRoger John Hilton and Amrik Sohal in 2012 make paper to examine the relationship between the successful deployment of Lean Six Sigma and a number of key explanatory variables that essentially comprise the competence of the organization, the competence of the deployment facilitator and the competence of the project lleaders.

The preliminary fieldwork involved interviews with two senior Master Black Belts; then, combined with the results of a literature review, the authors develop a conceptual model. A number of hypotheses are developed and the procedures involved in empirically testing these hypotheses are briefly explained.

Technical and interpersonal attributes of Black Belts and Master Black Belts are identified as well as the factors for success in deploying Lean Six Sigma. These factors relate to: leadership, communication, behavior and awareness of Six Sigma; policies, culture and organizational support and strategy; education, training and competency of the Six Sigma experts; project improvement teams and project management; and performance evaluations based on quality criteria, information systems, data and measurement.

The paper produces a predictive model for the successful deployment of a continuous improvement program such as Lean Six Sigma.[4]

In 2006 Tony bendle make paper to review and compare six sigma and the lean organisation approaches to process improvement. The basis for combination and compatibility is evaluated and a holistic approach proposed.

The examination is based on the author's extensive practical consulting and training experience with diverse six sigma, lean and business process improvement programmes in numerous companies

across Europe and worldwide, as well as theoretical development of his previous published work.

The paper contends that the current literature on the compatibility and combination of six sigma and lean is limited and disappointing when examined for a common model, theoretical compatibility or mutual content or method, but that they can be effectively combined into one system.

The study is experience-based and not supported by a specific-quantitative investigation.

Companies pursuing six sigma and lean implementation programmes need to carefully examine how the proposed initiatives relate to each other and other initiatives before fully committing, or at least to review the programme, to enable sensible programme design and management.

This paper focuses on six sigma and lean programmes in practice, rather than the theoretical basis or motivationally based argument. [5]

There is paper objective to analyze the critical success factors (CSFs) for lean Six Sigma (LSS) implementation and its impacts towards

company performance in multinational electronic manufacturing service (EMS) industries.

A pilot study has been conducted to identify the top ten CSFs for LSS implementation. Based on these factors, a structured questionnaire has been constructed. The questionnaire will be distributed to multi-sites of six EMS industries to obtain the data across Malaysia and other sites globally. The target population is the LSS program implementer such as master black belts, black belts and LSS champions in the EMS industries.

These EMS industries provide outsourcing platform for the original equipment manufacturing (OEM) industries to outsource their products in order to reduce operational cost. With the proposed LSS implementation success model, a practical guide of the LSS program has been implemented. The practical guide helps the LSS practitioners to focus on certain CSFs and it prevents the LSS execution from losing momentum when faces roadblock.

The paper is relevant to most EMS industries and provides guidelines to small and medium enterprises in Malaysia through improving their competitiveness and capability in the globalization market.

The EMS industries compete among themselves to gain more business from OEM industries through implementation of many improvements via cost reduction activities. LSS program is recognized among the EMS industries as one of the effective business strategy of cost reduction and to improve company's profitability and growth. The success of the LSS program in achieving the expected gain and return relies on CSFs; henceforth it renders the undertaking of this paper.[6]

CHAPTER THREE

METHODOLOGY

3-1 Methodology:-

Using lean six sigma(DMAIC) as a methodology to improve productivity

3-2(DMAIC) cycle phases:-

3-2-1 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

The first step in DMAIC procedures is to define the problems , 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

3-2-2 Measure

Measure what is causing the problem (X), Measure the quantity and prepare baseline capability .

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 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.

3-2-3 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.

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.

Other random variables can be defined to model the effect of incomplete applications, erroneous information and other types of errors and defects, and delays in obtaining information from outside sources, such as credit histories. By running the simulation model for many

loans, reliable estimates of cycle time, throughput, and other quantities of interest can be obtained.

3-2-4 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.

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.

3-2-5 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.

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 include a validation 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 should be factored into the plan.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 DEFINE PHASE :

4.1.1 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.

Table(4-1)SIPOC diagram

Supplier	Input	Process	Output	Customer
* production management * planning management * commercial management * financial management * foreign supplier companies	* raw material * machine * tools * man * machine spare - Part * electricity * Push car	<pre> graph LR START([START]) --> DRAWING[DRAWING] DRAWING --> HEAT_TREATMENT[HEAT TREATMENT] HEAT_TREATMENT --> WASHING_DRYING[WASHING & DRYING] WASHING_DRYING --> CUTTING[CUTTING] CUTTING --> STAMPING[STAMPING] STAMPING --> PUNCHING[PUNCHING] PUNCHING --> HEAT_TREATMENT_NECKING[HEAT TREATMENT FOR NECKING] HEAT_TREATMENT_NECKING --> NECKING[NECKING] NECKING --> GROOVING[GROOVING] GROOVING --> MECHANICAL_CONTROL[MECHANICAL CONTROL] MECHANICAL_CONTROL --> VISUAL_CONTROL[VISUAL CONTROL] VISUAL_CONTROL --> END([END]) </pre>	* Bullet case * rejected product *	* filling factory

4.1.2 VOICE OF BUSINESS:

Every project must start by this step ,We can calculate the losses profit from production plan during last 12 month (from January to December 2015) as following :

Table (4.2) different between plan and actual

Plan(%)	Actual production (%)	Losses (%)
100	20.3	79.9

This amount of losses = 17392.25 SDG

Companies typically suffer from huge hidden plants, which manifest as the cost of poor quality. By halving this cost, the companies Z 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 :

COPQ = 113514

4.1.3 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 (4.3) first time yield of process

NO	OROCES	RTY
1	Deep drawing-1	49.6%
2	Deepdrawing-2	100.0%
3	Trimming	80.3%
4	Stamping-1	120%
5	Stamping-2	83.3
6	Punching	105.5%
7	heat treatment-necking	190.9%

8	Shaping	74.5%
9	Grooving	33.3%
10	Mechanical control	199.9%
11	Visual control	200.1

RTY=79.4%

$\ln(\text{RTY}) = \text{TDPU}(\text{total defect per unit})$

Process working in RTY 79.4% will make 23 defect out of every 100 units approximately.

For a process working at Six Sigma levels, the RTY should always be 99.99996%, which will ensure a DPMO of 0.00034%, i.e. 3.4 DPMO

4.2 MEASURE PHASE :

4.2.1 MEASUREMENT SYSTEM ANALYSIS :

a. Determining the measurement method

The product between process are measured by weight of total barrel then minue 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 fill 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 real capacity of machine must to compute the productivity of machine per unit to compare capability of machine with a target .

Table (4.4) capacity of machines

<i>NO</i>	<i>PROCESS</i>	<i>CAPACITY UNIT/HR</i>
<i>1</i>	<i>DEEP DRWAING -1</i>	<i>7200</i>
<i>2</i>	<i>DEEP DRWAING -2</i>	<i>7380</i>
<i>3</i>	<i>CUTTING</i>	<i>7200</i>
<i>4</i>	<i>STAMPING- 1</i>	<i>5100</i>
<i>5</i>	<i>STAMPING- 2</i>	<i>4980</i>
<i>6</i>	<i>PUNCHING</i>	<i>9600</i>
<i>7</i>	<i>HEAT TREATMENT – NECKING</i>	<i>13800</i>
<i>8</i>	<i>SHAPING</i>	<i>5160</i>
<i>9</i>	<i>GROOVING</i>	<i>2640</i>
<i>10</i>	<i>MECHANICAL CONTROL</i>	<i>4900</i>
<i>11</i>	<i>VISUAL CONTROL</i>	<i>6360</i>

The team validated the design capacities provided by workshop managers by conducting sample time studies, noted a small variation of about 3% with the design capacities provided.

This variation is considered negligible and the team considers it is prudent to proceed ahead with further activities

4.2.2 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 tolerance may prove too costly in terms of the time and the extra machining it requires. Ideal tolerance 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 (4.5) drawing tolerances

Process NO	Diameter(mm)	Length (mm)
1st drawing	13.68__13.64	32.9__27.9
2nd drawing	12.23__12.20	62.3__67.3

Burning stage:

700c

trimming stage :

Table (4-6) trimming tolerances

Process NO	Length (mm)
Trimming	54__55

Burning stage for necking:

11.5__10mm

stamping stage:

table(4.7)stamping tolerances

Flanch diameter	15.6__14.5mm
Depth of hole	3 +0.15
Diameter of hole	5.43 +0.05
Height of anvil	1.5 +0.15
سمك الظفر	1.63 -0.16

Punching stage:

Tow hole with 0.8 +0.4 mm diameter each

grooving stage:

Table (4.8)grooving tolerances

بدايه زاوية ارتفاع الكتف	38.1mm
قطر فتحة الفم الداخليه	7.73 +0.05mm
قطر الرقبه الخارجيه	8.52 -0.48mm

Milling stage:

Table(4.9)milling tolerances

Flanch diameter	14.48 - 0.13mm
Case length	53.72 -0.37mm

4.2.3 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

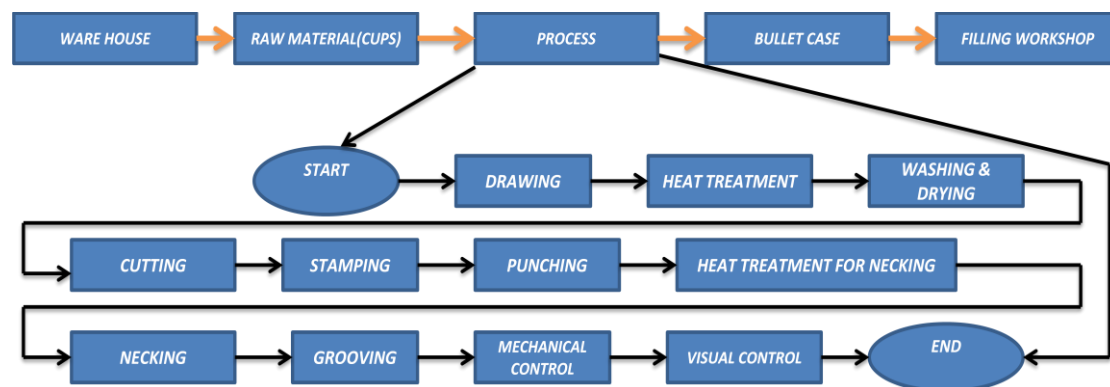


Figure (4.1) process map of manufacturing case

4.2.4 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.

Table(4.10) clarified the 44 sample of production

Table(4.10) production 44 sample during 2015

NO	CAPACITY	NO	CAPACITY	NO	CAPACITY
1	0	16	71000	31	0
2	0	17	70000	32	50000
3	0	18	59000	33	41000
4	7000	19	57000	34	53000
5	3000	20	37000	35	18000
6	9000	21	20000	36	5000
7	31000	22	47000	37	40000
8	53000	23	61000	38	36000

9	52000	24	30000	39	38000
10	39000	25	33000	40	56000
11	59000	26	52000	41	0
12	20000	27	39000	42	20000
13	26000	28	39000	43	36000
14	6000	29	16000	44	38000
15	40000	30	29000		

From the above table can check the normality of data with use normality test by mini tab.

A process should always have only common cause of variation

The first check for normality is Histogram. from table (4.10) must drawn Histogram to assure data normally distribution.

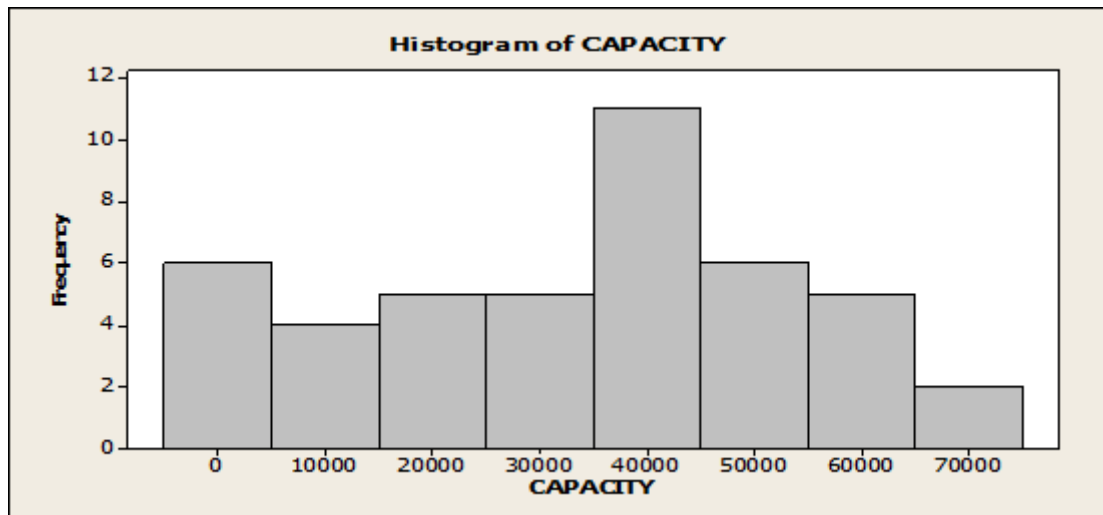
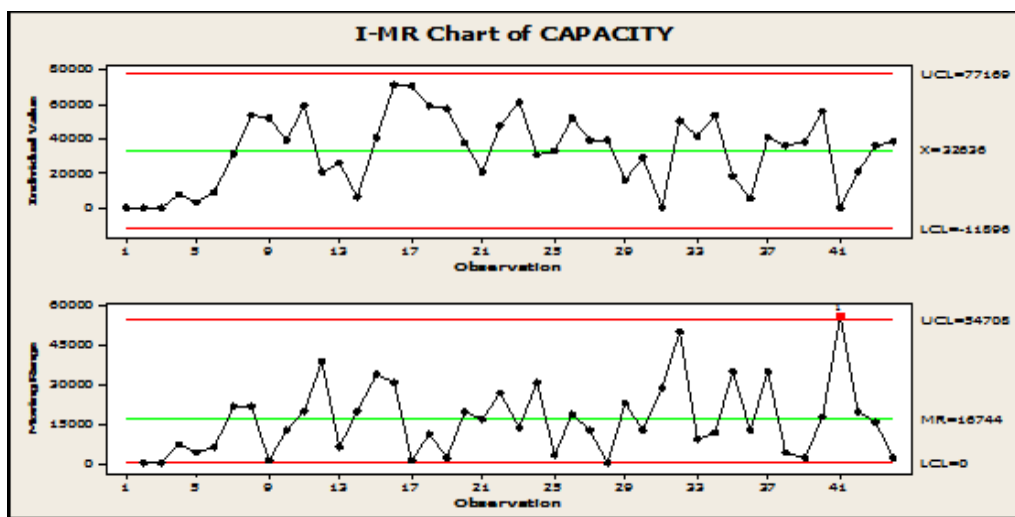


Figure (4.2) histogram for 44 sample

From the above figure found data is not normally distribution

The second test for normality is I-MR chart



Figure(4.3):I-MR chart for 44 sample

From the i-mr chart found that data is not normally distributed

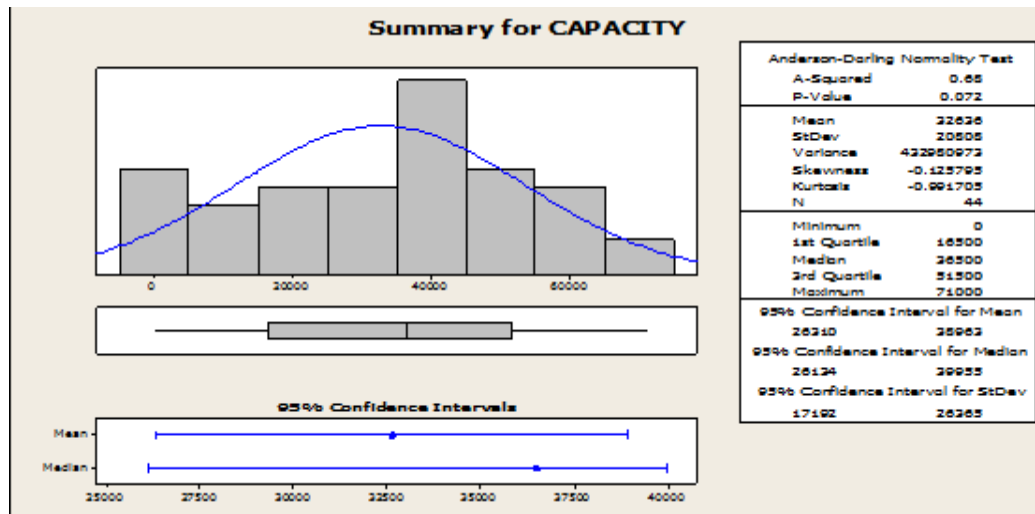


Figure (4.4)graphic summery for 44 sample of production

- i. Standard Deviation = 20505
- ii. Skew = -0.125795 (This should be 0 for perfectly normally distributed data) . Any skew > 1 or < -1 is unacceptable. Any skew value of < -1 or > 1 will result in data to be normally distributed.
- iii. Maximum – Minimum = Range of the data = $71000 - 0 = 71000$

SKEW AND KURTOSIS VALUES ARE $\neq 0$, DATA COMES FROM
NON- NORMAL DISTRIBUTION

4.2.5 CHECK FOR STABILITY :

Stability means consistency and predictability. the Stability checked with a tool called as Run Charts ,from table () can draw run chart .

From the figure (3.5) 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 = $0.016 < 0.05 \rightarrow$ Process data has special cause of variation.

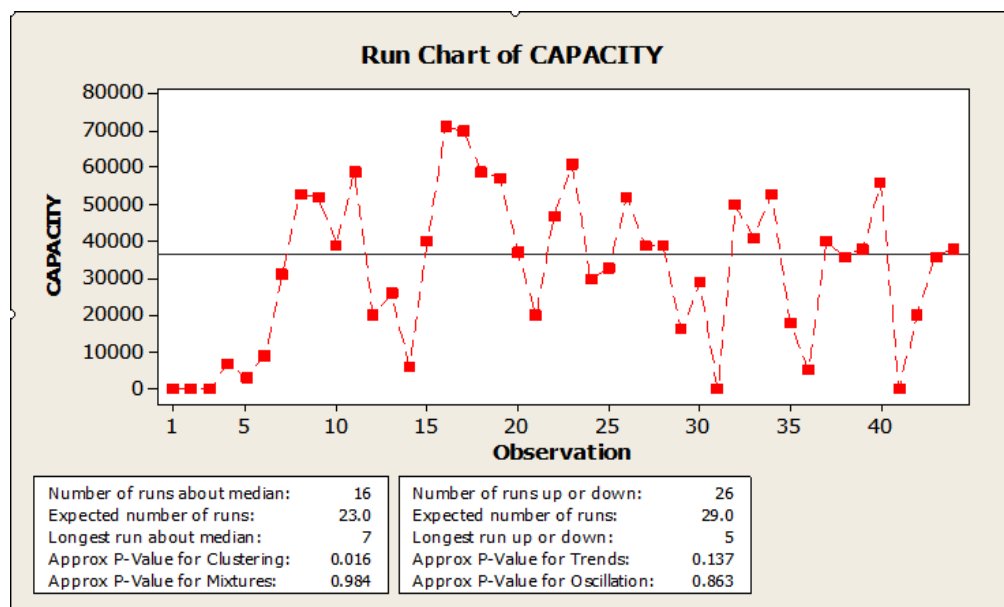


Figure (4.5) run chart for 44 sample of production

4.2.6 IDENTIFYING X VARIABLE AFFECT IN LOSSES .

There are many variables that affect performance . these variables are different some variables affect in quality of product , or in down time of machine. These variables may come from machine , spare part, tool ,labor or environment .

After collecting all variables must determine which one is controllable or not , then determine the availability of data for the variables .

The next step is flagging uncontrollable variables and collecting data for variables that don't have data .

Table (4.11) the probable problem affecting target

1	Tools
2	Rework
3	Defect
4	Mechanical specification of raw materials
5	Maintenance
6	Spare parts
7	Old machines
8	Heat treatment know how

9	In sufficient operator skills
10	Low number of labor

4.2.7 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 must to collect data to determine areason of dawn time . the following table clarified downtime during period of study .

Table (4.12) 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 (4.13) down time between process

Process	Dawn time
Drawing	13702
Trimming	13402
Stamping	9540
Punching	881
Necking	4320
Shaping	500
Grooving	1100
Mechanical control	51
Visual control	702

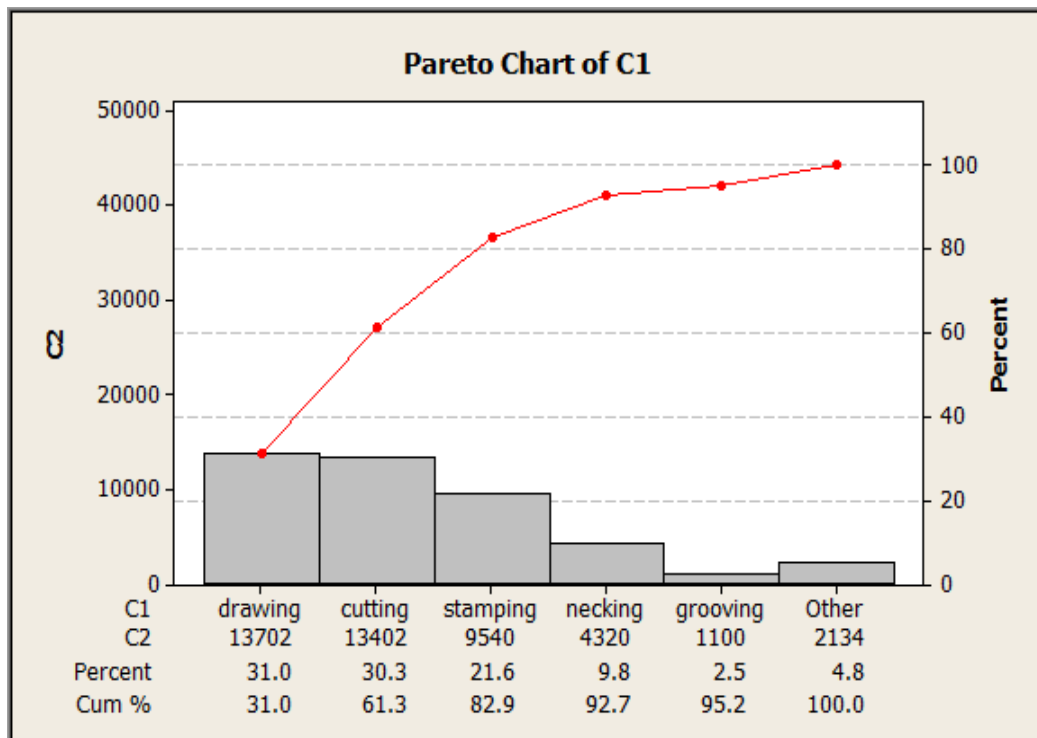


Figure (4.6) Pareto chart for down time machine

Approximately, 82% of our down time from drawing and cutting (trimming) machines . in the next phase will analyze above figure

4.3 ANALYZE PHASE :

4.3.1 CAUSE – AND– EFFECT DIAGRAM :

In situations where causes are not obvious, the cause-and-effect diagram is a formal tool frequently useful in analyzing 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 sub causes in each of these major categories and to prepare the diagram in Fig. (4.7). Then through discussion and the process of elimination, finally decided that tools and spare parts contained the most likely cause categories.

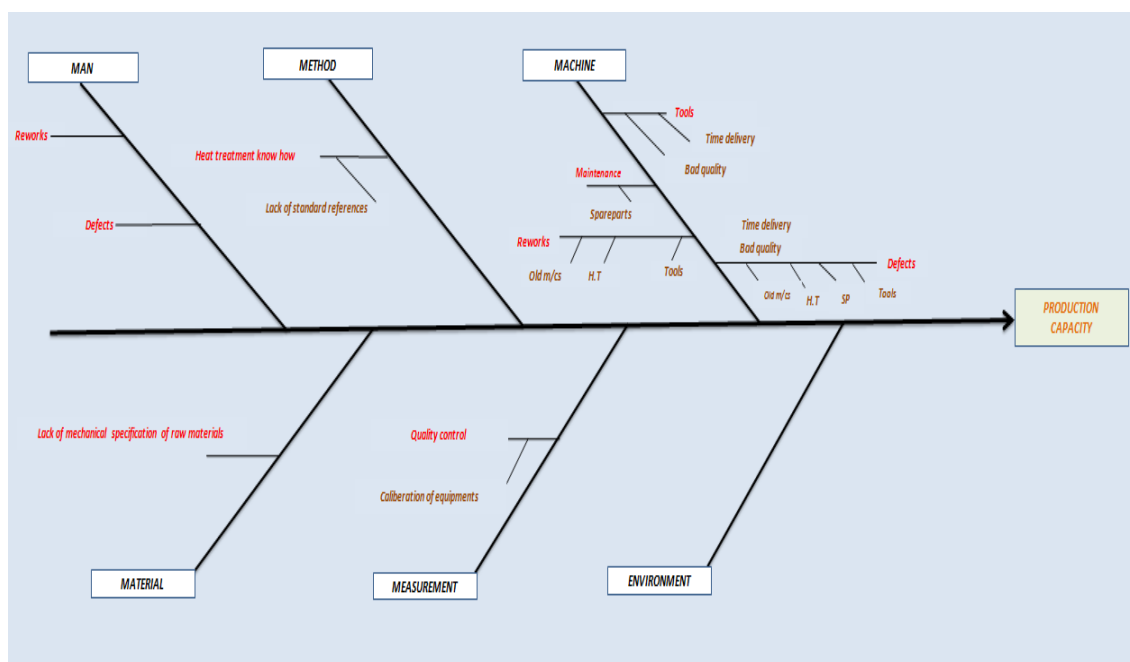


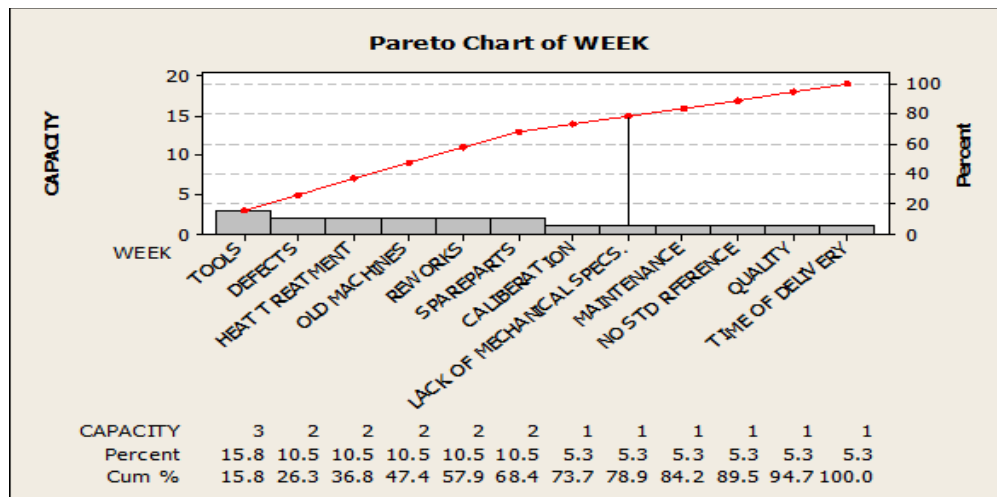
Figure (4.7) Cause-and-Effect Diagram:

Table(4.14) clarified the frequency of cause

NO	CAUSE	FREQUENCY
1	TOOLS	3
2	SPAREPARTS	2
3	HEAT TREATMENT	2
4	REWORKS	2
5	DEFECTS	2
6	OLD MACHINES	2
7	TIME OF DELIVERY	1
8	QUALITY	1
9	LACK OF MECHANICAL SPECS.	1
10	MAINTENANCE	1
11	NO STD RREFERENCE	1
12	CALIBERATION	1

Table(4.14):causes frequency

Form the above table can drawn pareto chart :



Figure(4.8):Pareto chart

4.3.2 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 case .

Table (4.15)Occurrence Rating

Occurrence Rating		Occurrence Rating	
1– 14 days	10	66–80 days	5
15–21 days	9	81–95 days	4
22–30 days	8	96–110 days	3
31–50 days	7	111–125 days	2
51–65 days	6	> 126 days	1

B. Detect ability

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

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 case, 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 (4.16)Severity Rating

Severity Rating		Severity Rating	
5 – 30 minutes	1	181–420minutes	5
31–60 minutes	3	2–7day	7
90–180minutes	4	>=week	10

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.

the process defects that have highest RPN taken firstly in improve phase

Table (4.17) FMEA analysis phase

Process Function (Step)	Potential Failure Modes (process defects)	Potential Effect(s) of Failure (Impact to Operations)	S E V	C l a s s	Frequency (days)	Potential Cause(s) of Failure	O C C	Detection ability?	D E T	R P N
Drawing	Accordion seal wearing	60 minutes	2	C	30		8	No	10	160
	Handle belt	30 min	1	C	180		1	No	10	10
	Handle rod	30 min	1	C	60		6	No	10	60
	seal wearing	2.5 hr	4	C	120		2	No	10	80
	Feeder electrical	60 min	2	C	7		10	No	10	200
	Feeder motor fault	3 days	7	C	180		1	No	10	70
	Feeder adjustable	4 hr	5	C	60		6	No	10	300
	Plastic handle	30	1	C	90		4	No	10	40
Cutting	Plastic handle	120 min	4	C	180		1	No	10	40
	Belts change	15 min	1	C	180		1	No	10	10
	Rod cutting change	30 min	1	C	14		10	No	10	100
	Feeder electrical	60 min	2	C	30		8	No	10	160
	Feeder motor fault	3 days	7	C	180		1	No	10	70
Stamping 1	Crank pins change	7 hr	5	C	120		2	No	10	100
	Striver wire change	5 min	1	C	90		4	No	10	40
	Pneumatic connectors check	60 min	2	C	30		8	No	10	160
Stamping 2	Flywheel pins change	1 day	5	C	180		1	No	10	50
	Striver roller rod	2 days	7	C	90		4	No	10	280
Punching	Transmission gears	2 weeks	10	C	180		1	No	10	100
	Feeder gear box sleeve	1 day	5	C	365		1	No	10	50
	Feeder belts	15 min	1	C	180		1	No	10	10
Necking	Screw copper sleeve	1 day	5	C	180		1	No	10	50
Shaping	Plastic handle wearing	3.5 hr	5	C	60		6	No	10	300
	Striver change	60 min	2	C	180		1	No	10	20
	Seals change	2 days	7	C	180		1	No	10	70
	Spring rod change	2 hr	4	C	120		2	No	10	80
	Torsion bearing	60 min	2	C	180		1	No	10	20
	Roller change	30 min	1	C	180		1	No	10	10
	Electrical faults	60 min	2	C	14		10	No	10	200
	Feeder motor fault	3 days	7	C	180		1	No	10	70

Grooving	Mandrel holder rod change	30 min	1	C	30		8	No	10	80
	Knife fixture change	30 min	1	C	21		9	No	10	90
	M/C cleanliness	180 min	4	C	14		10	No	10	400
	bearing change	60 min	2	C	30		8	No	10	160
	Belts change	60 min	2	C	60		6	No	10	120
	Gear box greasing	90 min	4	C	90		4	No	10	160
	Handle change	60 min	2	C	180		1	No	10	20
	Spring change	30 min	1	C	180		1	No	10	10
	Electrical faults	60 min	2	C	14		10	No	10	200
	Feeder motor fault	3 days	7	C	180		1	No	10	70
Mechanical control	Motor belt change	30 min	1	C	60		6	No	10	60
	Electrical faults	60 min	2	C	21		9	No	10	180
Visual control	Tool change	30 min	1	C	180		1	No	10	10
	Case block change	60 min	2	C	180		1	No	10	20
	Chain maintenance	120 min	4	C	180		1	No	10	40
	Plastic roller change	30 min	1	C	90		4	No	10	40
	Electrical faults	60 min	2	C	30		8	No	10	160

4.4 IMPROVE PHASE :

4.4.1 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. Because there is no

preventive maintenance we put instruction for stage to reduce down time and defects .

From the Analyze investigations, we found that No preventive maintenance , its mean must make work instruction form of critical fault detection and make check list for inspection for the output quality every 10 minutes for each machine .

Table (4.18) Daily instructions

Daily instructions

Date :.....

Shift :

Machine NO:.....

Stage :

	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 :

4.4.2 MODIFICATIONS :

there are Two modification are suggested and practically tested in the machine , the modification is :

1–Cutting Rod Design Modification

2–Add cover on the belts of grooving machine , this cover will protect the belt of motor and prevent injured of operators

4.4.3 UPDATE FMEA .

After modifications and check sheets and recommendations and taken action , the production is expected to improved and can observed the improvements in table (4.19) also the can observed the improvements from FMEA after updates .

Table (4.19) production improvement

Factory	Pre-Improvement / day	Reference (Dec 1 - Dec 11)	Improvement	Loss value to sale reduction(11 days)	Loss Value to Sale reduction yearly
Case	4904	80000	35864	\$6,321.03	\$1,75,584.17

The Yearly projections for the benefits have been done on the basis of the Improvement pilots. These calculations would need to be recalculated every month

table (4.20) FMEA after improve actions.

Process Function (Step)	Potential Failure Modes (process defects)	Potential Effect(s) of Failure (Impact to Operations)	Severity	Occurrence	Detection	D E T	R P I I	Recommend Actions	Responsible Person & Target Date	Taken Actions	S E V	O C C	D E T	R P I I
Drawing	Accordion seal wearing	60 minutes	2	C	30	No	10	Metal chips enter inside	Maintenance Engineer/Operator	Done	2	4	1	8
	Feeder adjustable	4 hr	5	C	60	No	10	Lack of ready backup spare part (Regulator of case)	Maintenance Engineer/Operator	On progress	5	5	1	25
Cutting	Rod cutting change	30 min	1	C	14	No	10	1-drawing should be change 2-Review the sharpening of knife and adjust weekly	Maintenance Engineer/Operator	Done	1	7	1	7
Stamping 1	Crank pins change	7 hr	5	C	120	No	10	Check & tight bolts daily	Maintenance Engineer/Operator	Done	5	1	1	5
	Pneumatic connectors air pressure variation	60 min	2	C	30	No	10	monthly check connectors and clean the regulator of air pressure.	Maintenance Engineer/Operator	Done	2	7	1	14
Stamping 2	Striver roller rod	2 days	7	C	90	No	10	Lubricate striver rod daily	Maintenance Engineer/Operator	Done	7	2	1	14
Grooving	Bearing damage	60 min	2	C	30	No	10	Daily machine cleaning and lubricating.	Maintenance Engineer/Operator	Done	2	3	1	6
	Belts change	60 min	2	C	60	No	10	covered and protect the belt and bearing. Check the belt every 45 days if it damage change it.	A.HAFIZ/MAINTENANCE	Done for one machine	2	3	1	6

Improve phase not only generates the solutions but also give feedback mechanism check the effectiveness of improvements.

Table (4.21) benefit after implement improve actions

No.	Factory	Improvement action	Impact	Cost of Improvement/SDG	Savings	Benefits
1	Case	Accordion Seal checked and cleaned weekly	Reduced downtime due to accordion seal feeder in Drawing machine	19,420	23,932	4,512
2		Cutting knife replacement	Reduced defects and reworks	1,841	1,846	5
3		Cutting Rod Design Modification	Reduction in cutting rod and cutting knife consumption, defects and downtime	1,013	7685	6,672
4		Fixing of bolts in the stamping machine	Reduce defects, downtime from Stamping stage.	2,873	10400	7,527
5		Add cover on the belts of grooving machine	Reduced downtime due to belt and bearing not breaking down due to chips	100	4037	3,937
6		Training for operators and maintenance personnel to check quality of tools	Reduced tool adjustment time due to bad quality tools.	-	-	-

3.6 CONTROL PHASE

The following table clarified control plan :

Table (4.22) control plan

Six Sigma Process Control Plan													
Process Name: 54 mm Case Production			Prepared by: GUMS Team			Page: _____ of _____			Document No: CFI				
Customer: Shagra Industrial Complex			Approved by: _____			Revision Date: 12/15/2014			Supersedes: _____				
Location: Shagra Industrial Complex			Int/Ext: _____			Approved by: _____							
Area: _____													
Sub Process	Sub Process Step	CTQ		Specification Characteristic	Specification		Measurement Method	Sample Size	Frequency	Who Measures	Where Recorded	Decision Rule/ Corrective Action	SOP Reference
		KPOV	KPIV		U.S.L.	L.S.L.							
Machine production	Drawing 1.2	Accordion Seal Downtime	Accordion Seal cleaning Weekly	Time	1 hour in a week	Downtime sheet	-		Weekly	Operator	Downtime sheet	Remove accordion seal every week, clean and return to machine	
		Machine runs for 3hrs/shift	Daily Allowed downtime 2hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 2hr		
Machine production	Cutting	Defect and Rework %	Change cutting knife weekly	Time	20 minutes/week	Downtime sheet			Weekly	Operator	Downtime sheet	Remove cutting knife and install ready one	
		Machine runs for 3hrs/shift	Daily Allowed downtime 1hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 1hr		
Machine production	Stamping 1.2	Machine downtime %	Maintenance time for bolts	Time	5 minutes/daily	Maintenance log			Daily	Maintenance	Maintenance log	Review bolts tightness of machine daily	
		Machine runs 2shift, 3hrs/shift	Daily Allowed downtime 3hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 3hr		
Machine production	Punching	Machine runs for 3hrs/shift	Daily Allowed downtime 2hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 2hr		
		Machine runs for 3hrs/shift	Daily Allowed downtime 1.5hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 1.5hr		
Machine production	Grooving	Machine runs 2shift, 3hrs/shift	Daily Allowed downtime 2hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 2hr		
		Machine runs 2shift, 3hrs/shift	Daily Allowed downtime 2hr	Case	4 Barrel/day	Production report		Daily	Supervisor	Production report	Produce 28000 case/day, with Allowed downtime 2hr		

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

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 , 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 trimming lines the actual cause of the defect might be from another department mostly from drawing . So forming a cross functional team with members from departments that are affected by the defect would add value and reduce the effort in identifying root causes. This Lean Six-Sigma integration was found to be an effective problem solving approach. If used repetitively, more improvement opportunities can be identified and studied. Systematic use of the proposed integrated approach can ensure savings in terms of time and money .

5-2RECOMMENDATION

- 1**– Provide tool and spare part to avoid down time
- 2**– Don't accept any tool off specification.
- 3**– Train operator as LSS concepts
- 4**– Put system for motivations to encourage operators
- 5**– to include lean six sigma in the syllabus of master program.

Reference:

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