Optimization of production process of Splitter Shoe using DMAIC methodology

A case study on Splitter Shoe

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***Abstract*—The DMAIC methodology is one of the most used techniques in the Quality Management field. Its benefits come from the improvement of the process by identifying and removing the root causes of defects. It is a disciplined, statistical and scientific problem solving technique, which uses statistical and non-statistical tools integrated with methodology to identify and eliminate number of defects. This paper provides implementation of DMAIC methodology for optimization of production process of splitter shoe. The purpose of this paper is to present the application of the DMAIC methodology which refers to a data-driven quality strategy for improving processes.**

***IndexTerms*—Optimization, Quality Management, DMAIC, Splitter Shoe**

I. INTRODUCTION

Companies are facing tough challenge to respond to the needs of customer while keeping manufacturing & other related costs down .Under DMAIC methodology Companies can cut down their costs by reducing the production of defective parts. All major issues related to product, processes are addressed using DMAIC methods.

Statistical Quality Control (SQC), Zero Defects and Total Quality Management (TQM), have been key players in quality management techniques from many years, while DMAIC is one of the more recent productivity improvement initiatives to gain popularity and acceptance in many industries. In providing background information, and giving evidence of the emerging importance of the methodology. These paper tend to explain the features of DMAIC rather than critically appraising or enhancing it.

II. LITERATURE REVIEW

(1) Hongbo Wang et al: This paper summaries, basic concept, DMAIC, DFSS and deployment.DMAIC is a closed-loop process that aims to identify and eliminate unproductive steps, often focuses on new measurements, and applies technology for continuous improvement. Then, some sectors that benefit from the implementation of DMAIC methodology are listed out, and the key factors influencing the successful project implementation are identified. This paper helps the readers to learn how to carry out a small-scale project with process improvement methodologies, including guidance on the application of tools.

(2) Senapati et al [2004]: has suggested DMAIC approach through deming cycle, TQM, MBNQA, and Dorian shanin's statistical engineering. He has suggested different methodologies as an improvement initiative.

(3) Antony et al [2005]: has presented the application of Define-Measure-Analyze-Improve-Control (DMAIC) methodology to reduce engine-overheating problem in an automotive industry. The experimental data collected during DMAIC project will provide a greater scope for the wider application of this methodology across the automobile companies in future.

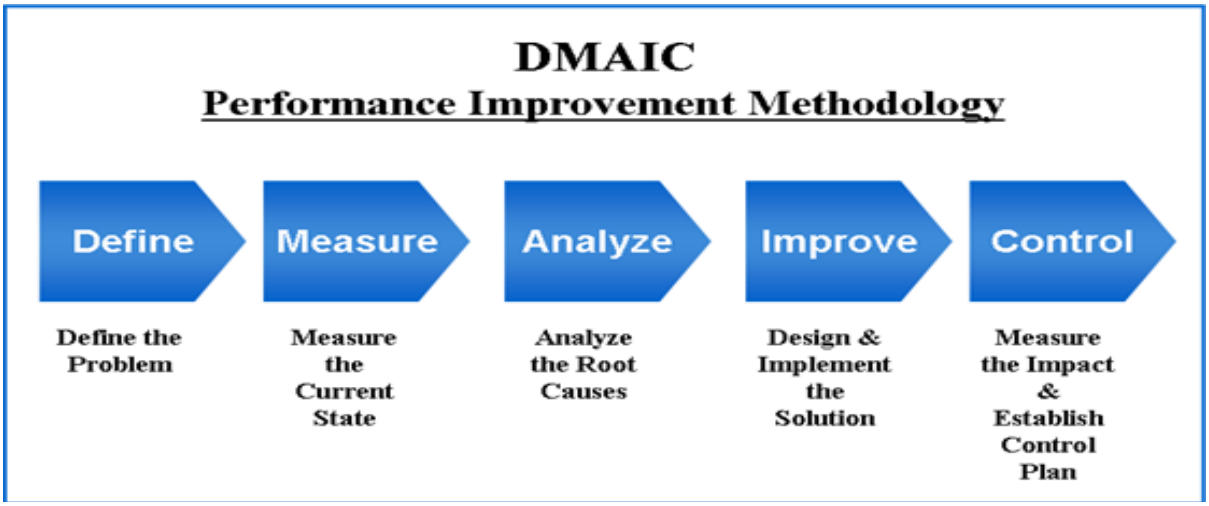
(4)Kumar and Sosnoski et al [2009]: has examined one of the shop floor chronic quality issue during heat treatment process through DMAIC methodology.

(5) Sahoo et al. [2008]: has implemented DMAIC in order to optimize radial forging operation. The authors had the prime focus on minimizing the residual stresses developed in the components manufactured by radial forging.

III. STEPS IN DMAIC

The Methodology basically consists of five phases effective for all target elements. Which are Define phase, Measure phase, Analyze phase, Improve phase and Control phase. These are to be executed while implementing any of the classified elements

Table 1



IV. ABOUT PRODUCT

SPLITTER SHOE- It is a product manufactured by the Jupiter Engineering Works that is used for industrial applications such as separating the fibre glass threads from each other while winding them. The production is yearly and the product manufactured is in batches of different types according to the order.

The processes done on Splitter Shoe are as follows-

1. Raw material- Bakelite Sheet of size 8 feet * 4 feet.
2. Cutting in pieces of 6 inch * 1 ½ inch by milling operation
3. Sorting in batches by thickness
4. Goes to CNC for cutting internal pattern
5. Buffing for smooth surfaces
6. Polishing for better finishing
7. Quality check
8. Packing and shipping

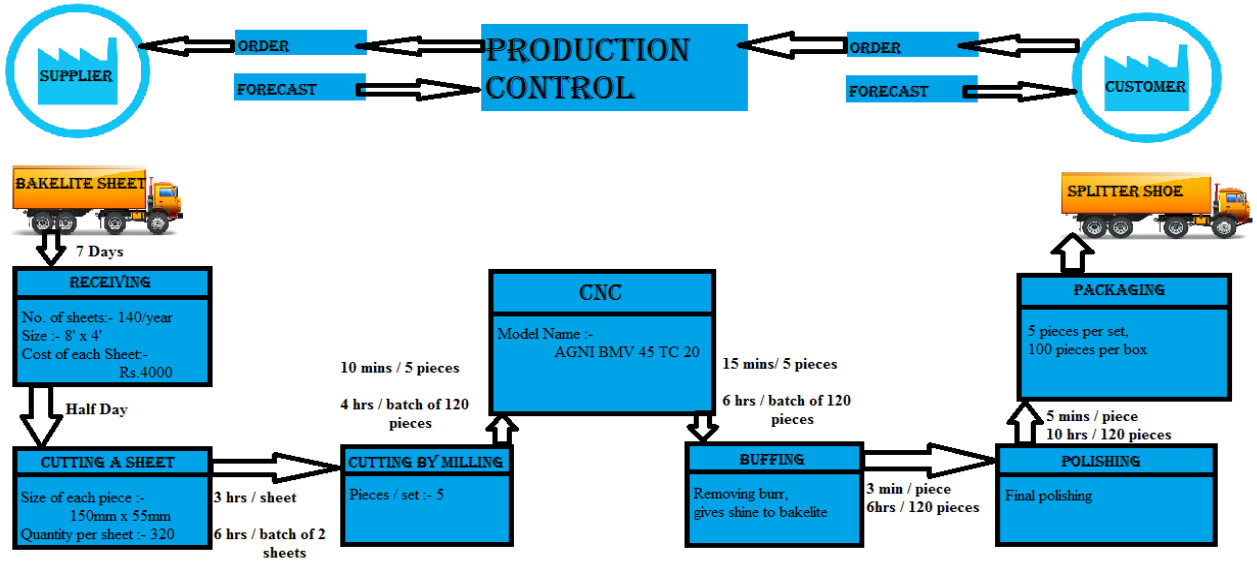
Types and series of Splitter shoe.

There are 2 major series of Splitter shoe as following

1. S- series: S series of Splitter shoe consists of smaller and variable types of shoes.
2. P- series: P series consists same size with different no of splits eg. 8P, 6P etc.

The first alphabet of the name of splitter shoe denotes the standard size of the shoe, and the digit after the letter denotes the number of holes in shoe for separating fibre glass.

Table 2



V. DETAIL STEPS IN PRODUCTION PROCESS

1. **RAW MATERIAL USED**- Bakelite Sheet

1. Bakelite has a number of important properties. It can be molded very quickly, allowing similar units to be produced on large scale.
2. Moldings are smooth, retain their shape and are resistant to heat, scratches, and destructive solvents.
3. It is also resistant to electricity, and prized for its low conductivity.
4. It is not flexible.
5. Phenolic resin products may swell slightly under conditions of extreme humidity.

When rubbed or burnt, Bakelite has a distinctive, acrid, sickly-sweet or fishy odor.

2. **CUTTING OPERATION**-

Usually done by circular saw. A circular saw is a tool for cutting many materials such as wood, plastic, or metal and may be hand-held or mounted to a machine. In woodworking the term "circular saw" refers specifically to the hand-held type and the table saw are other common forms of circular saws. Circular saw blades are specially designed for each particular material they are intended to cut and in cutting material are specifically designed for making rip-cuts and cross-cuts.

3. **MILLING OPERATION**:-

Milling is a cutting process that uses a milling cutter to remove material from the surface of a workpiece. The milling cutter is a rotary cutting tool, often with multiple cutting points. The milling cutter enters the workpiece, the cutting edges of the tool repeatedly cut into and getting off from material shaving off chips off the workpiece. The Milling is a cutting process where a milling cutter is used to remove material from surface of a workpiece. The milling cutter is a rotary cutting tool, often with multiple cutting points. The milling cutter starts cutting the workpiece, the cutting edges of the tool repeatedly cut into and exit from the material, shaving off chips from the workpiece with each pass. The cutting action is shear deformation; material is pushed off the workpiece in tiny clumps. Here, 8 pieces of dimensions 110x12.5 (smaller) PRIMARY SPLITTER SHOEOR 152x38 (larger) SECONDARY SPLITTER SHOE. Drill is also done of 4.2 mm diameter at 10mm from each end.

4. **CNC MACHINING**:-

CNC Machining is a process used in the manufacturing sector that involves the use of computers to control machine tools. Under CNC Machining, machine tools function through numerical control. A computer program is customized for an object and the machines are programmed with CNC machining language that controls all features like feed rate, coordination and speeds. With CNC machining, the computer can control exact velocity and positioning. CNC machining is used in manufacturing both metal and plastic parts. The model used in the industry is AGNI BMV 45 TC 20 and the control board of the CNC is by SIEMENS.

5. **SOFTWARES USED FOR DESIGNING**:-

- DELCAM:- DELCAM is a supplier of advanced CAD/CAM software for the manufacturing industry. It is a global developer of product design and manufacturing software. It now operates as a wholly owned, independently operated subsidiary of Autodesk.

In Jupiter engineering works DELCAM is used for complex 3d designs only.

MASTERCAM:- CNC Software is one of the oldest developers of computer based software. Master cam, CNC Software's main product, started as a 2D CAM system with CAD tools that let machinists design 3D parts on a computer screen and also guided computer numerical controlled (CNC) machine tools in the manufacture of parts. Since then, Master cam has grown into the most widely used CAD/CAM package in the world for CNC machines. Here, in Jupiter engineering works MASTERCAM is used for 2d or 3d designs.

6. **CHAMFERING AND POLISHING**:-

CHAMFERING- A chamfer is a transitional edge between two faces of an object. It can also be known as a bevel but connotes more often cutting and is forty five with respect to the two adjoining faces.

POLISHING-Polishing is the process of creating a smooth and shiny surface by rubbing it or using a chemical reaction, leaving a surface with some significant reflection. In some materials like metals, black or transparent stones. Polishing is also able to reduce diffuse reflection up to minimum values. When an unpolished surface is magnified many of times, it usually looks like peaks and valleys. The process of polishing with abrasives starts with coarse ones and graduates to fine ones. The strength of polished products is normally higher than their rougher counterparts.

7. **BUFFING**:-

For most, buffing means the use of a tool to correct and shine the surface of a metallic device or machined part. The tool used can vary from rotary buffers to orbital buffers. Buffing is often used in conjunction with a type of compound used to smooth the surface of material. These are fine abrasives added to greases to create rectangular solid sticks or fluids. A number of buffing methods exist. There is cut buffing which involves cutting down the surface of brass, copper, and other metals and coloring it at the same time. Next there is color buffing. This process involves using polishes or buffing compounds to give a mirror-like smooth shine. Colour buffing is usually done once the surface of have become sufficiently smooth.

VI. IMPLEMENTING DMAIC

A. **DEFINE Phase:** In order to implement the DMAIC Methodology it is crucial to define the process as well as problem associated with it The purpose of this step is to clearly articulate the goal, business problem, potential resources, and high level project timeline. This information is captured within project charter document. Define the following:

- A critical problem
- What are the critical process outputs?
- The project boundaries – Where does the process begin and end?
- The process to be improved

The details of define phase are as follows-

Table 3

Project Title: - Optimization of production process of splitter shoe using DMAIC methodology.	
Background and reasons for selecting the project:- A large amount of splitter shoe were rejected by the manufacturing company due to defects. This problem causes several types of losses to the company, for example: time, materials, capital as well as it creates customers' dissatisfaction, which negatively affects the organization image.	
Project Goal: To reduce the defects by 34% after applying DMAIC into the splitter shoe manufacturing process.	
Voice of the Customer (VOC):	Product's quality
Project Boundary:	Focusing the splitter shoe solely
Team members:	• Jogesh Pawar • Bhavesh Kondhalkar • Nachiket Kulkarni • Suyog Pawar
Expected Financial Benefits:	A considerable cost saving due to the defects reduction
Expected Customer Benefits:	Receiving the product with the expected quality

B. **MEASURE phase:** this is a data collection step, the purpose of which is to establish process performance baselines as the basis for improvement. The performance metric baseline from the Measure phase will be compared to the performance metric at the conclusion of the project to determine whether significant improvement has been made. It involves;

- Develop a plan for the collection of data for the process
- Gather data to identify types of defects
- The data was collected using a Digital vernier caliper, and the measured data is classified as per the defects as follows -

Table 4

Sr. No.	Cause of Defect	Sept-Oct	Nov	Jan-Feb	Total
1.	Bending	512	300	726	1538
2.	Incorrect Cutting of sheet	59	48	83	190
3.	Chipping while Milling	103	81	146	330
4.	Initial CNC Program Error	10	-	-	10
5.	Excess of Buffing and Polishing	70	51	90	211
6.	Shipping	-	47	-	47
7.	Miscellaneous	14	8	17	39
	TOTAL	768	535	1062	2365

C. **ANALYZE Phase:** The intention of this step is to identify and select root cause for elimination of defects or any causes of errors. A large number of potential root causes of the project problem are identified via root cause analysis. The root causes were identified using several tools. This process is repeated until "valid" root causes can be identified. it involves;

- Identify how the process inputs affect the process outputs. Data are analyzed to understand the magnitude of contribution of each root cause, Statistical data tested using p-values with Pareto charts, bar graph, Histograms, and line plots are often used to do this.
- Opportunities for improvements are prioritized
- Sources of variation are identified

Table 5

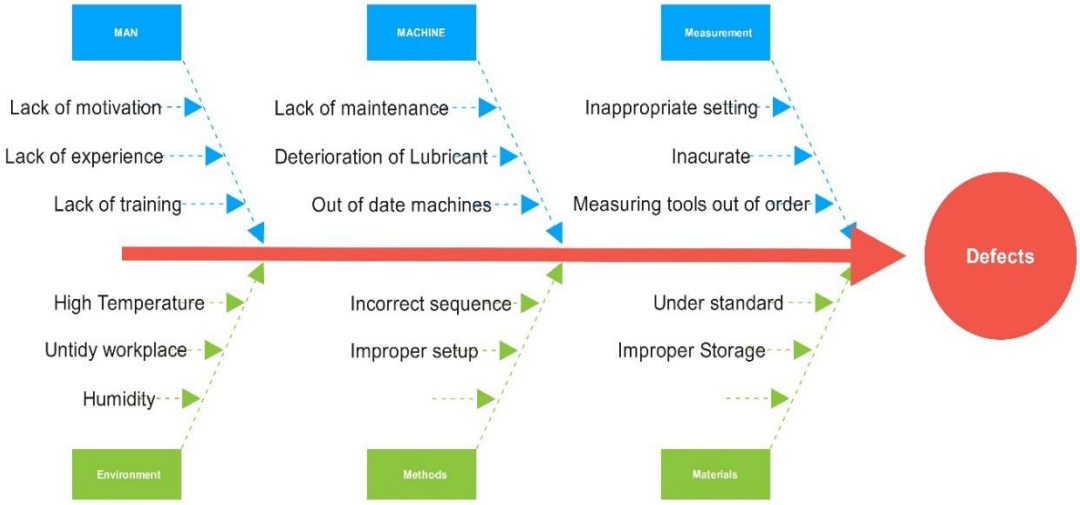
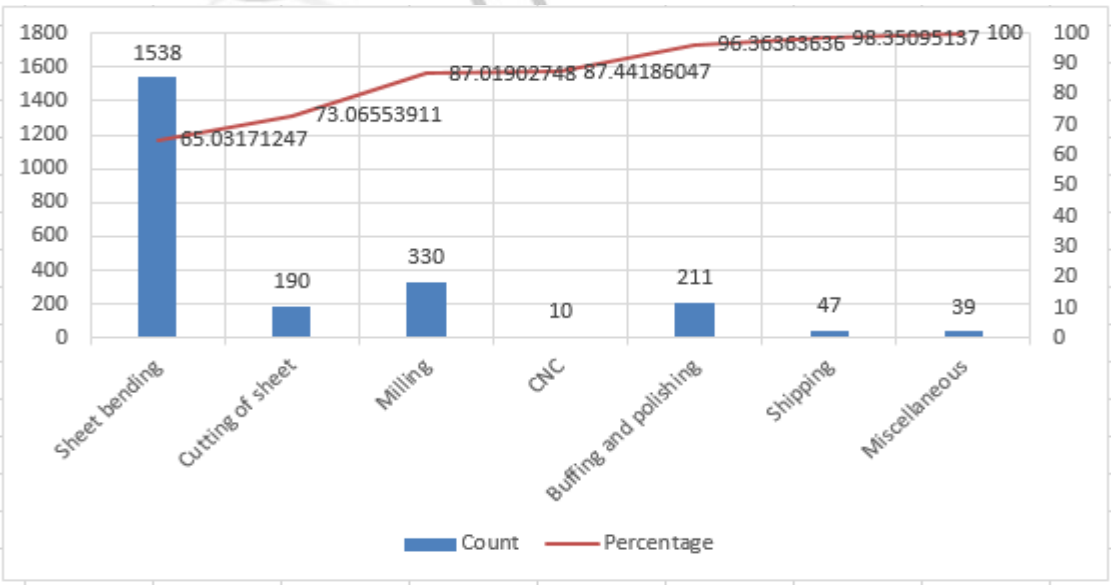


Table 6

Sr.No	Type of Defect	Count	Cumulative Count	Percentage
1	Sheet bending	1538	1538	65.0317125
2	Cutting of sheet	190	1728	73.0655391
3	Milling	330	2058	87.0190275
4	CNC	10	2068	87.4418605
5	Buffing and polishing	211	2279	96.3636364
6	Shipping	47	2326	98.3509514
7	Miscellaneous	39	2365	100

Table 7



D. **IMPROVE Phase:** This step is recommended to identify, test and implement a solution to the problem, in part or in whole project. This depends on the situation. Identify creative solutions to eliminate the key root causes for fixing and preventing process problems. The purpose of this step can also be to find solutions without implementing them it involves;

- Create
- Focus on the simplest and easiest solutions
- Create a plan to improve
- Implement it

Using the data from the implementation of the above it is now possible to improve the process by designing easy and unique solutions to fix and prevent problems. This is achieved by using technology to build innovative solutions to Develop and implement a plan.

We identified the cause of defects in splitter shoe which causes 80 % of problem.

The improvements suggested to the company are 1) Reducing size of the sheet to 4 feet*4 feet

2) Use of better fixtures with guiding scale

E. **CONTROL Phase:** The purpose of this step is to monitor the improvements to ensure continued and sustainable success. Create a control plan. Upgrade business documents and training records as required. A Control chart is useful while the Control stage. It assist is the stability of the improvements over time by serving as a guide to continue over viewing the process.

Control and sustain improvements over time by –

- Developing, documenting and implementing upgrading plan
- Integrating the improvements throughout the company through the use of training, staffing and incentives.

Control phase should be conducted by company after the changes were applied.

VII. RESULT: By 20-80 cause and defect principle, eliminating top 20% causes that produce 80% of defects.

1) As all bending defects cannot be eliminated, assuming 75% of the bending defects are eliminated.

i.e. actual defects due to bending= 1538,

Defects after reducing raw material sheet size= 1538-(1538* 0.75) =385

2) Incorrect cutting of sheet can be eliminated totally hence eliminating defects due to that

Hence defects due to incorrect cutting = 0

Therefore total defects after elimination = 1022

As the defects reduced from 14.59% to 6.3%

Hence defects reduced by = 56.78%

Hence the increment in sigma level is achieved.

VIII. CONCLUSION: .Based on this methodology, further research can be accomplished in manufacturing company. This paper gives incisive insight into the existing method of manufacturing splitter shoe. Basically DMAIC methodology is beneficial both for manufacturing or service concerns and Large or small scale organizations. It is more essential to learn how to enhance the productivity and improve its implementation issues for the growing number of firms or organizations that are choosing to adopt it with the aim of process improvement. The primary focus was on improving overall organizational performance, not just pinpointing and counting defects.

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