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Research Paper

REDUCTION OF WELDING DEFECTS USING SIX SIGMA TECHNIQUES

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In this paper discusses the quality and productivity improvement in a manufacturing enterprise through a case study. The paper deals with an application of Six Sigma DMAIC (Define-Measure-Analyze-Improve-Control) methodology in an industry which provides a framework to identify, quantify and eliminate sources of variation in an operational process in question, to optimize the operation variables, improve and quality performance, viz., process yield with well executed control plans. Six Sigma improves the process performance (process yield) of the critical operational process, leading to better utilization of resources, decreases variations and maintains consistent quality of the process output. In this Paper identifies the root causes of failure for a welding process at a manufacturing plant and proposes to use Operational Six Sigma technique to eliminate the problem. In contrast to other method which measure and identify the nonconformance through destructive testing, a technique is proposed to use a mathematical model, which is later charted using SPC technique. The control chart for the mathematical model identifies the failure of the process in real time and will reduce/eliminate the testing process.

Keywords: Quality Management, Six Sigma, DMAIC Process, Statistical Process Control

INTRODUCTION

Total Quality Management (TQM): It has evolved as a strategic approach in most of the manufacturing and service organizations to respond to the challenges posed by the competitive business world. Today TQM has become a comprehensive management strategy which is built on foundation of continuous improvement and organization wide involvement, with core focus on quality. TQM is a process of embedding quality awareness at every step of production or service while targeting the end customer. It is a management strategy to embed awareness

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of quality in all organizational processes. By pursuing the process of continuous improvement and never-ending improvement the companies can out distance their competitors by enticing the customers with high quality products at low price. TQM has culminated Six Sigma, which targets 99.99927% defect free manufacturing (Tushar N Dasia and Shrivastava, 2008).

SIX SIGMA

Six Sigma is considered as a methodology of implementing TQM. Six Sigma is an innovative approach to continuous process improvement and a TQM methodology. Since quality improvement is the prime ingredient of TQM, adding a Six Sigma program to the company's current business system covers almost all the elements of TQM. Six Sigma has become a much broader umbrella compared to TQM (Tushar N Dasia and Shrivastava, 2008).

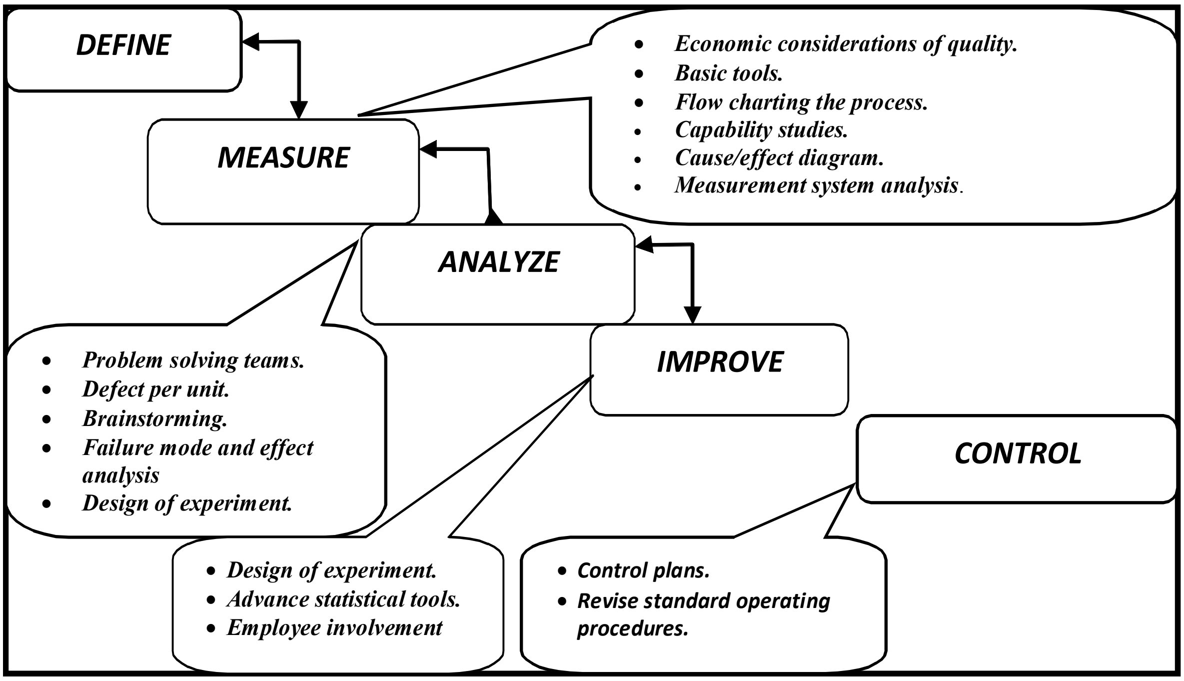
THE DMAIC SIX SIGMA METHODOLOGY

The DMAIC is a basic component of Six Sigma methodology—a better way to improve work process by eliminating the defects rate in the final product. The DMAIC methodology has five phases define, measure, analysis, improvement and control.

Define Phase

Goal: In this phase, define the purpose of project, scope and process background for both internal and external customers. There are a different tools which is used in define phase like SIPOC, Voice of Customer and Quality Function deployment.

Figure 1: DMAIC Methodology for Running Six Sigma Project



Output

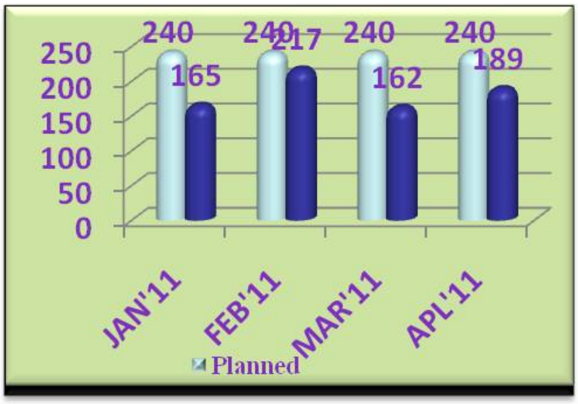
1. A clear understanding of process improvement and how is it measured by the
2. Implementation of different tools.
3. High level of process is achieved.
4. A lot of successful factors list show that what customer requirement is?

SAW machine process is lowest in the given period; a Pareto chart illustrates in Figure 2. It was decided to increase this project. Table 1 presents the team charter for this project.

Table 1: Project Team Charter

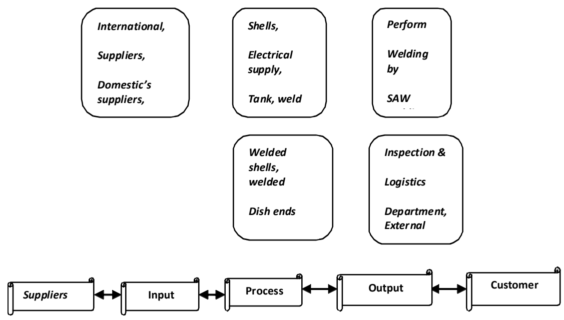
Deptt. Name	TQM Facilitation & Industrial Engineering Deptt.
Project Location	A large scale manufacturing unit, Surat, Gujarat, India.
Project Start Date	11-January to 11-April.
Business Case	Improvement in SAW welding process will reduced COPQ, non-production idle hours, delay in delivery of jobs; which will satisfy the customer, which will lead to improvement in quality, production and good products.
Project Title	Reduced the welding defects using Six Sigma techniques.
Team Member	Mr. Shashank Soni, (M-Tech, student) and employees of the QA/QC Deptt.
Stake Holder	Employees of TQM facilitation & Industrial Engineering Deptt.
Subject Matter Expert	Sr. manager, HOD, Industrial Engineering Deptt.
Phase of projects	Define phase Measure Phase Analyze phase Improve Phase Control Phase

Figure 2: Pareto Chart Showing SAW Welding Process



Describes the transformation process of inputs form suppliers to output for customers and gives a high level understanding of the process, the process steps (sub processes) and their correlation to each other.

Figure 3: SIPOC Diagram



Process Deliverables

1. Reduction of non-production idle hours.
2. Reduction of COPQ.
3. Increase in SAW welding machine process yield.

Principal Customers

Internal customers are:

1. Project management group.
2. Manufacturing shops.

3. Inspection departments.

External customers are:

1. Clients / Third party Inspectors.
2. Customer Representatives.

Defining Process Boundaries and Customer CTQ Requirements

Process Boundaries - Process Start Point: Un-welded Rolled shell from PFS shop, SWP & WPS of the job.

Process Stop Point: Welded Shell which is ready for inspection clearance.

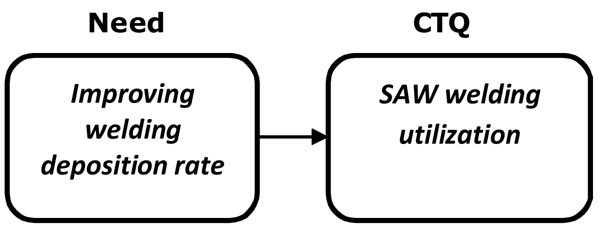
Customer CTQ Requirements

The customer data (VOC) revealed that internal customers are mainly affected by low SAW machine welding process yield. CTQ characteristics are established and a CTQ tree (Figure 4) is prepared on the basis of the VOC and project objective.

Measure Phase

This phase presents the detailed process mapping, operational definition, data collection chart, evaluation of the existing system, assessment of the current level of process performance, etc.

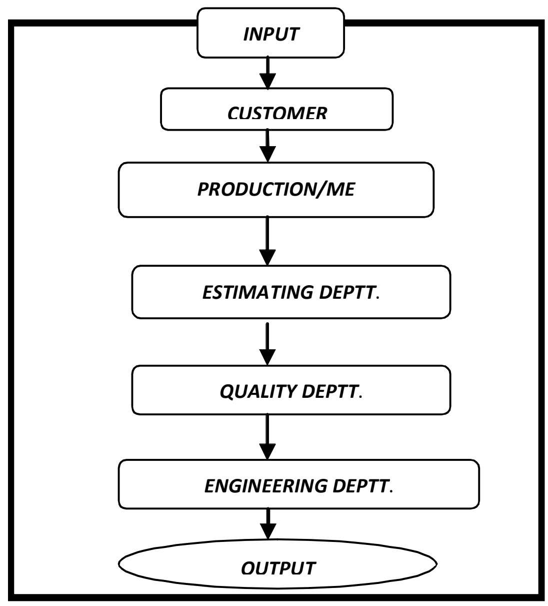
Figure 4: Critical to Quality Tree (CTQ tree)



Process Mapping

The process map of the SAW welding process (Figure 5) is prepared by visually studying the process and then mapping various sub-activities in it. This mapping helped to visualize and separate value-added.

Figure 5: Process Mapping Diagram of SAW Welding Process



Operational Definition

SAW welding machine process is defined as the ratio of net operating hours to gross available hours

Type of Data

The type of data is continuous (variable).

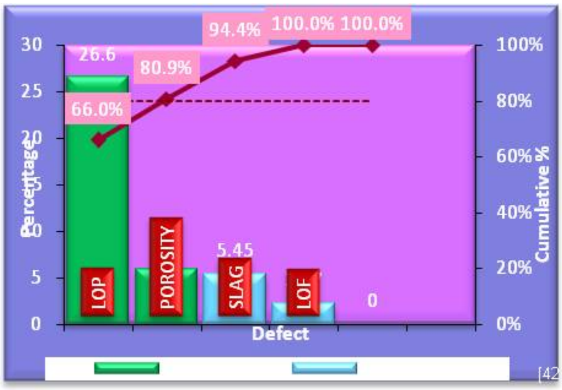
Assessing current level of process performance (process sigma level).

$$SAW\ Welding\ Process = \frac{Net\ Operating\ hrs.}{Gross\ Available\ hrs.}$$

Analyze Phase

The analyze phase is the third step in the DMAIC improvement cycle. This section describes the work and result of the cause and effect diagram, Pareto analysis of the causes, Why-Why analysis, is which identify to identify the few factors in order to identify the root causes of the defects/problems and helped to examine the processes that affect the CTQ.

Figure 6: Pareto Analysis Diagram



Why-Why Analysis

Figure 8 Shows a why-why diagram which helped in identifying root cause of the problem.

Improve Phase

The goals of this phase are to select problem solution, recognize the risks and implement selected solution. Practically, the improvement must investigate necessary knowledge based on brainstorming to create the best solution.

Brain Storming

"This figure shows results after the solution of defect in controlled condition, hence the action is validated on the basic of data collection."

Main project implementations by expected benefit are:

Tangible Benefits

- Production efficiency increase by section/ day.
- Reduction in COPQ by 50%.
- Saving of INR 8,43,000.
- TPT reduced by 2 days,

Intangible Benefits

- Customer satisfaction.

Figure 7: The Causes and Effect Diagram

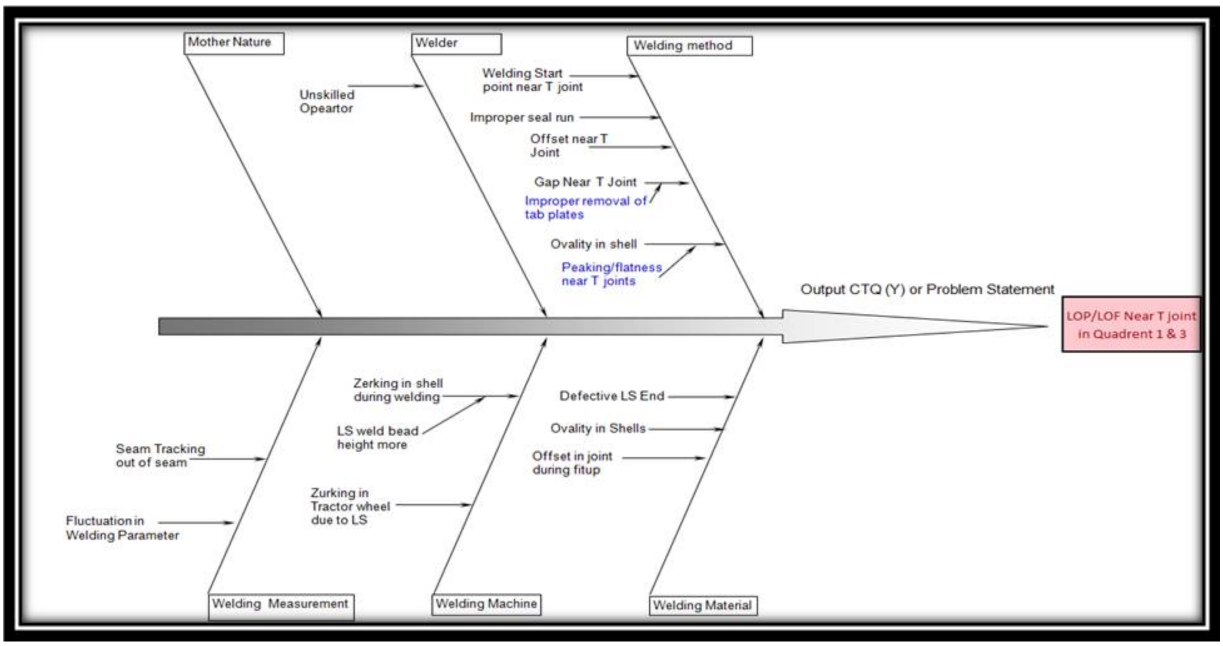
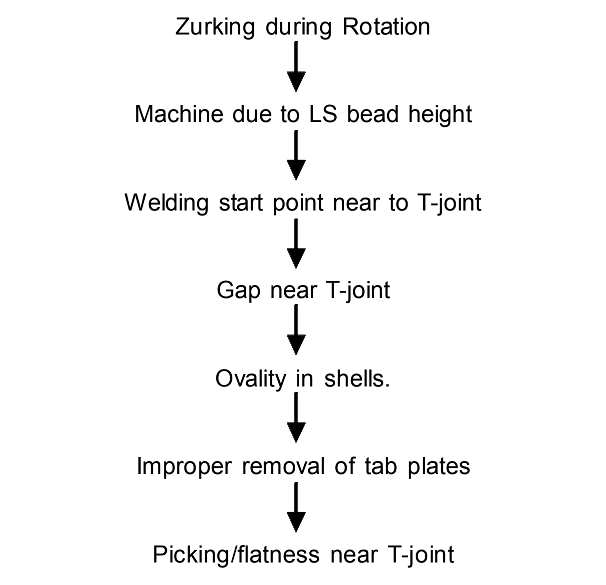
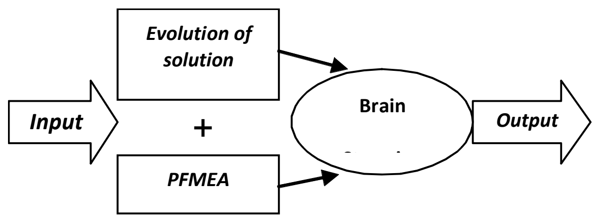


Figure 8: Why-Why Analysis





- Availability improvement (OTIF),
- Possibility of failure reduced.

Cost

- Cost of tooling.
- Cost of training, gauges development.

Benefits

- Reduction in 0.02 defects/ MW.
- Reduction in welding rework.
- Improved availability of section for blasting and painting for commissioning.

Impact on Business Goals

- Throughput time reduction by 2 days against existing.
- COPQ to be reduced by 50%.

Table 2: Final Action for Validation Method

Causes	Final Actions	Validation Method	Y/N
Improper removal of tab plates	Grinding photo to be displayed in SOP	DOE	Y
Improper Weld groove	Gauge development	DOE	Y
Welding start point near to T joint	To specify to start welding from 90 degree to T-Joint in SOP	Data collection	Y
Ovality in shells	Monitoring sheet to be made to check waiting time Resting platform to be made for shell storage	Data collection	Y
Zurking of tractor machine	To Specify the way of grinding how to grinding with photo for visualization	Data collection	Y
LS Bead height more than 1.5 mm	Gauge development	DOE	Y

Figure 8: The Machine Process of Structure

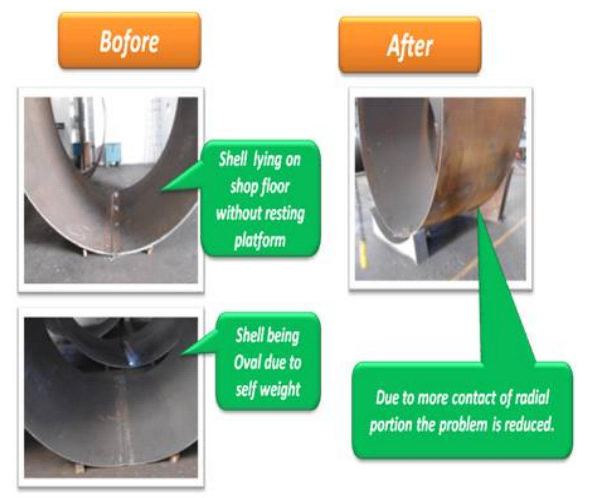
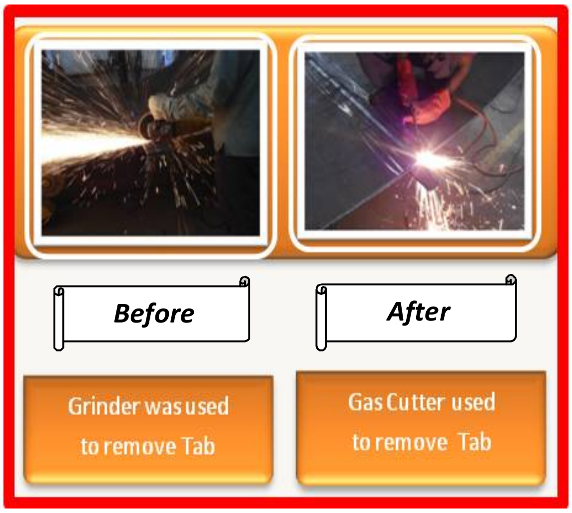


Figure 9: Implementation Process



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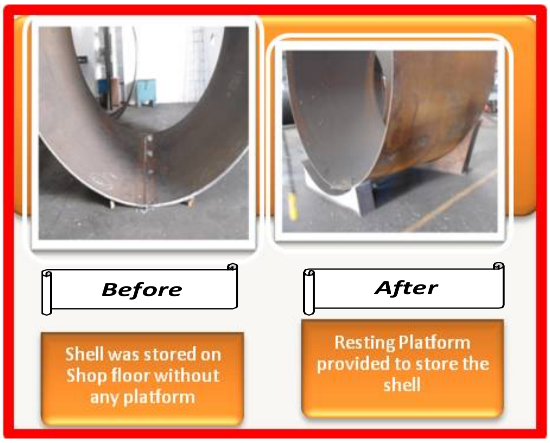

(b)

Control Phase

The last phase of DMAIC is control, which is the phase in which we ensure that the processes continue to work well, produce desired output results, and maintain quality levels. This is about holding the gains which have been achieved by the project team.

Implementing all improvement measures during the improve phase, periodic reviews of various solutions and strict adherence on the process yield is carried out.

The Business Quality Council executed strategic controls by an ongoing process of reviewing the goals and progress of the targets. The council met periodically and reviewed the progress of improvement measures and their impacts on the overall business goals.

Project implementation (Realized benefits):

Tangible Benefits

- Saving (Approx INR 8.431).
- Rework of defect trend is in decreasing and now 4.8 defects/section.
- After implementation ROI is 0.2.

Intangible Benefits

- Improved customer satisfaction.
- Reduced possibility of failure.
- Improved availability.
- Closure of potential failure mode.

In this, final phase of DMAIC methodology, a control plan was developed to ensure that processes and products consistently meets our and customer requirements, and to check how external/internal welding process on quality production level

RESULTS AND DISCUSSION

Six Sigma is an effective way to find out where the greatest process needs are and which the softest points of the process are. Also, Six Sigma provide measurable indicators and adequate data for analytical analysis. Systematic application of Six Sigma DMAIC tools and methodology within an automotive parts production results with several achievements.

The achieved results are:

- Reduced possibility of failure.
- Reduced costs of poor quality (CORQ).
- Reduced labors expenses.
- Improved customer satisfaction.
- Closure of potential failure mode.

Also, the significant results are achieved by two indexes that are not dependent on the volume of production:

- Production time reduction.
- Index cost/volume reduction.

Generally, improvements through reduced Production time, Control time, Material and Internal scrap.

Conducted improvement project based on Six Sigma methodology provides close acquaintance with all phases of process while Six Sigma tools enables right decisions and the most significant improvements.

Definitely, Six Sigma is powerful methodologies that can, properly implemented, result with significance savings and improvements.

CONCLUSION

Operational Six Sigma methodology was selected to solve the variation problem in a welding process. The study proposal a real time monitoring system by which the shear strength of the weld can be eliminated, without destructive resting. Due to 100% inspection, error made by the selective sampling can be eliminated, reducing the scrap page cost. The implementation of the new system will pay for itself in a long run.

This Six Sigma improvement methodology, viz., DMAIC project shows that the performance of the company is increased to a better level as regards to: enhancement in customers' (both internal and external) satisfaction, adherence of delivery schedules, development of specific methods to redesign and reorganize a process with a view to reduce or eliminate errors, defects; development of more efficient, capable, reliable and consistent manufacturing process and more better overall process performance, creation of continuous improvement and "do it right the first time" mindset.

Six Sigma provides business leaders and executives with the strategy, methods, tools and techniques to change their organizations. Six Sigma as a powerful business strategy has been well recognized as an imperative for achieving and sustaining operational (process) effectiveness, producing significant savings to the bottom line and thereby achieving organizational excellence. If implemented properly with total commitment and focus, Six Sigma can put industries at the forefront of the global competition.

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