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Six Sigma Technique for Quality Improvement In Valve Industry

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Abstract*— Manufacturing processes tend to produce operational wastages due to various reasons, which can be reduced by identifying and eliminating those using Six Sigma methodologies. In the presented work, DMAIC (Define, Measure, Analyze, Improve and Control) has been used to reduce in machining time, cost of the tool, number of defects in control valve cylinder head manufacturing and valve body manufacturing industry. Core issues, pain areas or processes are identified to formulate the problem. Later the concerned data is collected to examine the current performance; also the root causes are identified. Solutions are found out from improvement point of view, and various tools are properly implemented for tracking the processes. This study reports reduction in defects in manufacturing industry through reduction in DPMO (Defects per Million Opportunities) from 1401 to 603.47, also the Sigma Level is improved from 4.5 to 4.8.

***Keywords*— Six Sigma; Control Valve Cylinder Head and Valve Body Manufacturing Industry**

I. INTRODUCTION

Machining time, cost of the tool, number of defects minimization plays very important role in manufacturing industry. In today's competitive scenario price, services, promptness, performance of the product are major factors. Wastage of time and capital affects price of the product and decreases the profit level of the company or industry. Therefore process industries always try to reduce operational wastages. Any process does not produce pure final product, there are always some unwanted byproducts which add cost to the final product and do not add value to the final product, these are called as operational wastages. To tackle this problem Six Sigma is very useful methodology. Six Sigma is statistical business improvement approach deals with finding and eliminating defects and their causes in every business operation and focusing the goal most important to costumers. Six Sigma is a high-performance, data-driven approach to analyze the root causes of business problems and solving them [1]. From the statistical point of view, the term Six Sigma is defined as having less than 3.4 DPMO or a success rate of 99.9997 % where Sigma is a term used to represent the variation about the process average [3]. In the business world, Six Sigma is defined as a business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations [2]. In Six Sigma approach tool namely: DMAIC. The overall approach to solve problem by using DMAIC methodology which includes conversion of practical problem in to statistical problem and finding statistical solution, these statistical solutions are converted into practical solutions and are implemented properly in the organizations [5]. The company involved in this study is Control Valve Cylinder Head and Valve Body Manufacturing Industry. It is one of leading industry in the Vidarbha region in central India. In this study different tools of Six Sigma have been used with objective to reduce operational wastages. The paper is organized as follows: Section 2 discusses the problem definition and the methodology. Complete implementation is elaborated in the section 3. Finally the results and discussion is presented in section 4 followed by the references.

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2. Problem Definition and Methodology

The valve body is made of Grey Cast Iron on which R120 op is to be performed. This valve is used on back side of tractor to lift the gauge used to plough the field. The identification of problem in the company was surrounded to the facts that more were the defects and hence more was the cost of poor quality (COPQ). The major problem was also concerned about the presence of vibrations. The idle time was too much. The lesser tool life was great problem. We can't even neglect the problem of casting and an unavoidable difference between basic and desired dimensions.

3. Six Sigma DMAIC Methodology

DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applied technology for continuous improvement [3]. Implementation of DMAIC Methodology took place in five phases as outlined earlier and established at Motorola. Problem identification and definition takes place in define phase. After identifying main processes, their performance is calculated in measure phase with the help of data collection. Root causes of the problem are found out in analysis phase. Solutions to solve problem and implementing them are in improve phase. Improvement is maintained in control phase.

ROADMAP TO SIX SIGMA –

- **DEFINE**- Set project goals and objectives
- **MEASURE -** Measure the defects where they occur.
- **ANALYZE -** Evaluate data/information for trends, pattern and root causes,
- **IMPROVE -** Develop, implement and evaluate solution targeted at identified root causes
- **CONTROL -** Make sure that almost the problems have cleared, and method is improving

3.1 Define Phase

This phase determines the objective and scope of the study. Information about the present processes is collected, determination of customers and deliverables to customers are also determined.

3.1.1 Project Charter, Project Plan and Process Flow Map

The Project Charter defines the scope, objectives, deliverables and overall approach for the work to be completed. It is a critical element for initiating, planning, executing, controlling, and monitoring the study.
Table 1 shows the details of project title, business case, problem statement, in scope, out scope, expected customer benefit.

Project Title	Reduction of operational wastages of Valve Body.
Business Case	Due to quality of manufactured Valve Body, reduction in customer satisfaction.
Problem Statement	Average Success rate of meeting customer's cpk commitments are varying with average cpk of 1.3
In Scope	Improvement in critical operation of Valve : R120 op
Out Scope	All other manufacturing process
Expected Customer Benefit	Customer requirements are satisfied.

Complete project plan for the work to be completed is- **Define**: 1st August 2008 to 30th September 2008;**Measure**: 1st October 2008 to 30th November 2008; **Analyze**: 1st December 2008 to 31st December 2008;**Improve**: 1st January 2009 to 30th February 2009; **Control**: 1st March 2009 to 30th April 2009.

3.2 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. In the measure phase, performance of process in pain areas is determined and operations data was collected. To collect the data, plan for data collection was prepared and the data was collected for the period July 2008 to October 2008 which is given in Table 2.

Months	July 2008	August 2008	September 2008	October 2008
Parts Produced	4140	4145	4303	4535
Rejected Parts	19	17	15	21
Rejection (%)	0.459	0.41	0.348	0.463

3.2.1 Calculation of Sigma Level of Company

- Total number of parts produced in 4 months = 17123
- Total number of parts rejected = 72
- Average rejection = 0.42

$$DPMO = \left(\frac{\text{Number of defects}}{\text{No.of opportunities } \mathbf{X} \text{ No. of Units}} \right) * 1,00,000$$

$$= \{ 72 / (3 \text{ X } 17123) \} * 1,00,000$$

$$= 1401$$

The sigma level as per the DPMO comes out to be 4.5. Apart from the sigma level following important facts was summarized as below.

Table 3: Summary of Measure Phase

Sr. No.	Particulars	Data
1.	Cost of machining	Rs.325
2.	Cost of Casting	Rs.266.5
3.	Cost of three index tool	Rs.705
4.	Machining time (per piece)	5.45min
5.	Total number of defects	72 out of 17123
6.	Cost of defects per piece	Rs.602.10
7.	Role of COPQ in total cost	0.42 %
8.	Total parts produced per day	90

3.3 Analyze Phase

The analyze phase is the third step in the DMAIC improvement cycle. This section describes the work and results of the cause and effect diagram to identify probable causes. This phase describes the potential causes identified which have the maximum impact on the operational wastages.

3.3.1 Cause and Effect Diagram

A cause and effect diagram (Figure 1) for presents a chain of causes & effects, sorts out causes & organizes relationship between variables.

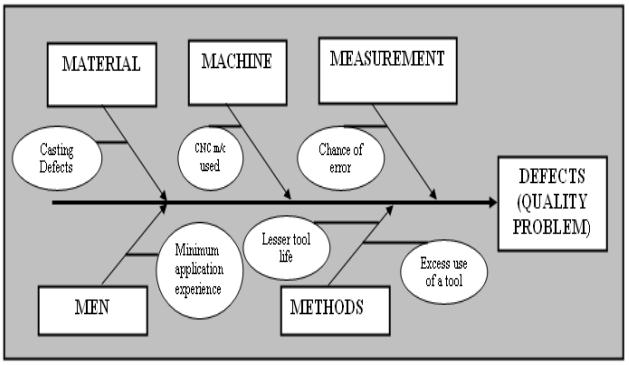

Figure 1: Cause and Defect Diagram for Defect

3.3.2 Pareto Chart

The Pareto chart is prepared to prioritize defects and to find out probable causes. Specific data collected was analyzed to prioritize root causes and the same was validated by using statistical techniques. After analyzing the data, it is found out the major causes for less quality.

Table 4: Summary for Pareto Chart

Sr. No.	Causes of Defects	No. of defects
1.	Ovality	39
2.	Casting	18
3.	Manual Mistakes	12
4.	Tool failure	03

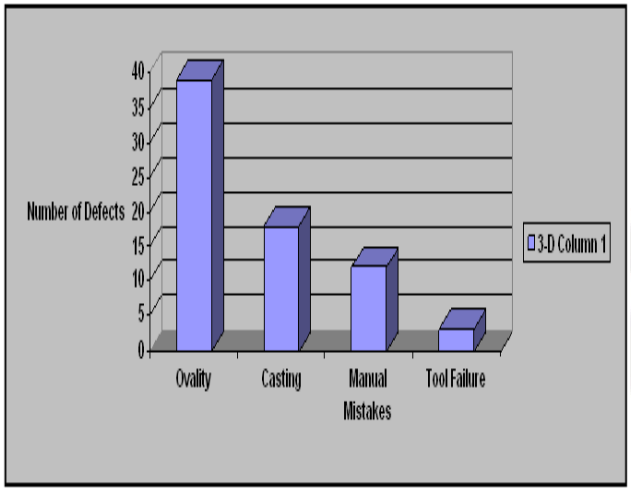

Figure 2: Pareto Chart

3.4 Analyze Phase

The Improve phase is the fourth step in DMAIC improvement cycle and its aim is to find and implement measures that would solve the problem. This phase involves improving processes/product performance characteristics for achieving desired result and goals. This phase involves application of scientific tools and techniques for making tangible improvements in profitability and customer satisfaction.

Table 5: Proposed Solutions for Profitability and Customer Satisfaction

Critical To Quality (CTQ)	Cause Validated	Proposed Solution
Profitability And Customer Satisfaction	Casting defects	Defects are typically detected and discarded before they affect valve life.
	Tool changing time	By using combination tool, the additional time of tool changing is reduced.
	Manual mistakes due to conventional lathe machine	Rate of material removal can be increased by using CNC machine
	Unusual stresses causes ovality on work part	Avoid manual clamping of work part i.e. valve body.

3.4.1 Calculation of Sigma Level of Company

- Total number of parts produced = 17123
- Total number of parts rejected = 31

$$DPMO = \left(\frac{\text{Number of defects}}{\text{No. of opportunities } \mathbf{X} \text{ No. of Units}} \right) * 1{,}00{,}000$$

$$= \{ 31 / (3 \text{ X } 17123) \} * 1{,}00{,}000$$

$$= 603.47$$

The sigma level as per the DPMO comes out to be 4.8

Table 6: Summary of Improve Phase

Sr. No.	Particulars	Before DMAIC Methodology	After DMAIC Methodology

1.	Cost of machining	Rs.325	Rs.325
2.	Cost of Casting	Rs.266.5	Rs.266.5
3.	Cost of three index tool	Rs.705	Rs.535
4.	Machining time (per piece)	5.45min	1.45min
5.	Total number of defects	72 out of 17123	31 out of 17123
6.	Cost of defects per piece	Rs.602.10	Rs.602.10
7.	Total parts produced per day	90	180

3.5 Control Phase

This is the last phase of DMAIC methodology. In this phase, large emphasis is given on proper implementation of solutions. For this, regular checking of check charts were carried out. Monitoring of pain area was done shift wise, day wise and month-wise. The improvements should be adhered to by providing training to the staff, implementing various incentives schemes and adhering to the modified systems.

3.5.1 Approach of control phase

- Inspection of cast material before machining, so that it helps to considerable extent.
- Comparator, air gauge to measure the dimension of the parts at regular interval of time.
- Strictly follow process monitoring chart.
- Recruitment of skilled employee of each field.
- Maintenance of tool regularly.
- Continuous evaluation.

Table 7: Summary of Control Checks at Control Phase

Sr. No.	Operations	Check
1.	How to run CNC	Check all the previously set parameters and programme.
2.	Accurate measure of Bore	Insert the gauge exactly normal.
3.	How to set the Tool	Read the manual first.
4.	How to set the Work part	See the clamp first then apply usual torque to assure good clamping.

4. Result and Discussion

The Six Sigma based methodology has been used to optimize the operational wastage. The results obtaind are in the form of improvement for profitability in DPMO, Sigma level (Previous =4.5, Improved=4.8). It has been found that organization achieved breakthrough in reducing operational wastage due to Six Sigma DMAIC Methodology. Six Sigma was found to be the greatest motivator behind moving everyone in the organization and bringing radical transformation. People in the workplace have developed the required statistical thinking with their involvement in this particular study. Benefits of implementation have been found to be enormous in this case study. However further research is possible in the direction of what the people and organization has to sacrifice for getting this breakthrough in their process.

As no gains possible without companying improvement in work habit Six Sigma is continues improvement process involving all operations in the work place and more such opportunities are potentially available in the workplace.

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