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Quality Management through Six Sigma in SSI (Small Sector Industries)

Rahul Mishra[1] and Praveen Singh[2]

[1,2]Shri Rawatpura Sarkar Institute of Technology -II Near Radiant Public School, Champaran Road, Raipur (Chhattisgarh), India
E-mail: [1]rahul.mishra.10j@gmail.com, [2]singh.praveen96@gmail.com

Abstract—*Six Sigma has proved that it is the best statistical technique for improving quality of the product and productivity of the company. In present work, an attempt has been made to introduce Six Sigma to Indian SSI. This case study discusses the successful introduction of Six Sigma strategy in Indian small scale industry by improving the quality of a product which is getting high level of rejections. The study aims to strongly highlight the importance and benefits of Six Sigma implementation to different organizations for improving the quality of the product which ultimately results in the improvement of the competency power which is essential in today‘s world*

1. INTRODUCTION

Although Six Sigma is typically first implemented to improve manufacturing, During the past half of the century, more than 69 quality related initiatives have come into existence. Statistical Process Control (SPC), Quality Circles (QC), Total Quality Management (TQM), Bench Marking, Quality Management Systems (QMS), ISO 9000 Quality Management System (QMS) Standard and other such initiatives have created a visible impact in the business world. Quality professionals have perpetuated the _Keep it Simple‘formula for performance measurement over the past 70 years in an effort to have the greatest impact on businesses. The classic tools and metrics have been applied differently in a competitive environment.

It is a fact that all the production methods and processes are subjected to variability. The variations that occur into the processes are classified into two groups, first we have the variations due to inherent causes or common causes, and these are unavoidable causes of variability inherent to the nature of the process. These causes produce a distribution of values which is approximately normal and which is predictable. The other group of variations is due to special causes, which are caused by special changes into the process or environment. For instance, one of the components fails, improper material is used, the adjustment of the equipment is incorrect, etc. However, for the survival and economic stability of any organization, its capacity utilization must be improved. Due to continuously rising population, higher interest burden, rising inflation, declining GDP it is very important to increase capacity in countries like India.

An organization has several objectives. These are not only in form of products to be manufactured and marketed but also include goals of capacity utilization, achieving profitability as well as intangible objectives of customer satisfaction and societal goals. Resources are utilized as inputs to achieve these objectives. For improvement of capacity, an organization requires improvement plans, identifying actions desired, fixing responsibilities and laying down of time schedules. Operational management encompasses all facts related to the art and practice of capacity and for its successful implementation, it is necessary to have an organization, an audit system and a monitoring plan.

Six Sigma is both a philosophy and a methodology that improves quality by analyzing data with statistics to find the root cause of quality problems and to implement controls product. The method can also be used in other business processes, such as product design and supply chain management. Although Six Sigma has its roots in large corporations, it can be used in small to medium-sized companies as well. Small companies are typically more agile and may have an easier time getting management team commitment, but they may have more difficulty with committing employee time and funds for training. So in present work, a case study has been selected where an attempt has been made to implement the Six Sigma strategy to small scale sector in India and remove the fault that raises the cost of product and reduces capacity utilization. The present work discusses the real life case where Six Sigma has been successfully applied at small-scale unit to improve one of the core processes, illustrating the use of Six Sigma methodology. DMAIC (define, measure, analyze, implementation and control) methodology with DOE has been implemented at the unit. The industry manufacturing car locks faces high rejection rate due to extra effort used while locking. So, after implementation of Six Sigma results have shown a impressive reduction in rejection rates of the product.

2. DMAIC: A SIX SIGMA TOOL

The discipline of six sigma views every business activity as a process, that once optimized and controlled, reduces cost. Hence, Six Sigma itself is a process that is often briefly described by the acronym DMAIC, which stands for define, measure, analyze, improve, and control. First, the stability testing process, or process issue, needs to be defined. Second, since stability testing itself is a measuring process, its capability needs to be measured. Third, the capability of the process needs to be analyzed in order to determine if it is delivering what is required (accurate stability predictions or estimates), and if not, improve. Finally, control the stability testing process by insuring that the improvements that have been implemented are maintained through time. DMAIC is a process for continued improvement. It is systematic, scientific and fact based. This closed-loop process eliminates unproductive steps, often focuses on new measurements, and applies technology for improvement.

DMAIC refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC improvement cycle is the core process used to drive Six Sigma projects. DMAIC is not exclusive to Six Sigma and can be used as the framework for other improvement applications. It implements the idea of continuous process improvements. Processes are constantly monitored for possible improvement possibilities

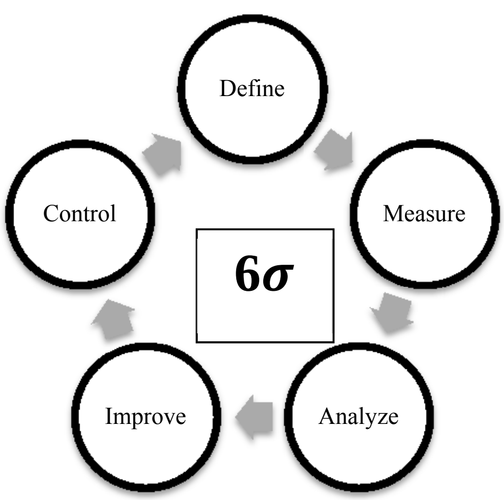

Fig. 1: Five Phases of DMAIC

Table 1: Key Steps of DMAIC Processes

Steps	Key Processes
Define	• Define the requirements and expectations of the customer • Define the project boundaries • Define the process by mapping the business flow
Measure	• Measure the process to satisfy customer‘s needs • Develop a data collection plan • Collect and compare data to determine issues and shortfalls
Analyze	• Analyze the causes of defects and sources of variation • Determine the variations in the process • Prioritize opportunities for future improvement
Inspection	• Improve the process to eliminate variations • Develop creative alternatives and implement enhanced plan
Control	• Control process variations to meet customer requirements • Develop a strategy to monitor and control the improved process • Implement the improvements of systems and structures

3. SIX SIGMA AS AN IMPROVEMENT PHILOSOPHY

Sigma has been defined as an improvement philosophy, particularly by GE. GE claims that Six Sigma is its business strategy, corporate culture, company DNA and value, and ―the way we live‖ (GE, 2002). Regardless of the terms used, the essence is to define Six Sigma as an improvement philosophy. Defining Six Sigma as an improvement philosophy is very inspiring and it could lead to major cultural change and performance improvement in an organization.

Six Sigma Statistics:

Statistical problems can be solved using the tool named as Six Sigma. The nature of statistical problems is can be of different type. One is problem with spread or variation as shown in Fig. 2.

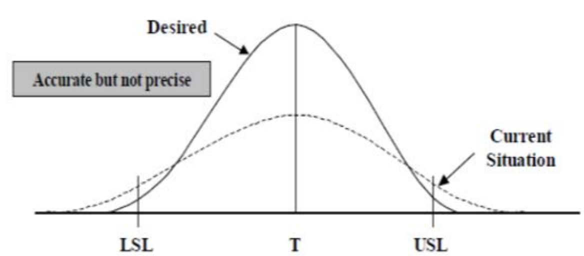

Fig. 2: Problem with Spread or Variation

Most of the quality and management problems are due to the existence of product variations. If variation could have been eliminated all defects and non conformities would have been eliminated. This type of problem is mainly associated with product industries. Another type of statistical problem can be of problem with centering as shown in Fig. 3 and this mean value type of problem is mainly associated with process industry where consumption rate is very high and to reduce consumption rate, statisticians have to develop methodology and tools for estimating, comparing, controlling and reducing mean value.

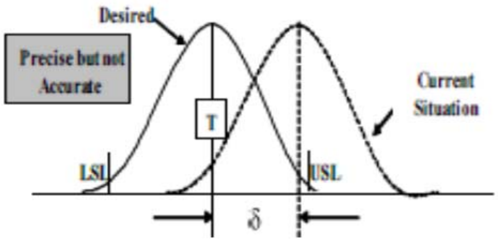

Fig. 3: Problem with Centering

In statistics, sigma denotes the standard deviation of set of the data and the sigma value of the process describes the quality level of that process. A process is centered when X=T, where X is the process average or mean and T is the target value which is typically the midpoint between the customers upper specification limit (USL) and the lower specification limit (LSL). A Process is off-centered when the process average, X, does not equal the target value T. the off-centering of a process is measured in standard deviations or sigma which provides a measure of variability, indicates how all data points in a statistical distribution vary from the mean(average) value. The quality level indicates how well that process is performing and achieving productivity. The higher the quality level (2, 3, 4 etc.), the better will be the productivity and Sigma measures the capability of the process to perform defect free work.

Six Sigma is a disciplined, data driven approach and methodology for eliminating defects (driving towards six standard deviation between the mean and the nearest specification limit) (Desai and Patil, 2006). The statistical representation of Six Sigma describes quantitatively Six Sigma is a disciplined, data driven approach and methodology for eliminating defects (driving towards six standard deviation between the mean and the nearest specification limit) (Desai and Patil, 2006). The statistical representation of Six Sigma describes quantitatively.

Table 2: Sigma Level and Corresponding DPMO

Sigma	Percent Yield	Defective PPM
6	99.9997%	3.4
5	99.98%	233
4	99.4%	6,210
3	93.3%	66,807
2	69.1%	308,537
1	30.9%	691,462

4. CASE STUDY

The main product of company is locks and one variety of lock is hood latch lock as shown in Fig. 4.. Initially the company was facing higher rejection rates due to the tight movement of hook of hood latch lock. That has created ―Hook not return‖ complaint in long stay automobiles. Hence it has become essential to validate the design of the product without changing the riveting specification due to the high rejection rate and willingness of staff and management to reduce rejection rate. In the entire case study all the parts used to make Hood Latch lock are considered.

Fig. 4: Hood hatch lock

This phase involves selecting product characteristic, mapping respective process, making necessary measurements and recording the results of the process. Firstly, in this phase we tried to find out the factors which are critical to quality and after that used Gauge R&R study to determine whether the tool used for measuring the diameter of spring is working properly or not. **Factors Critical to Quality** are categorized in two categories which are further classified. They are:-

- **Process Variation**
  Assembly Riveting Process
- **Input Product Variation**

a) Hook Thickness
b) Washer Thickness
c) Hood Base Thickness
d) Rivet Height
e) Spring Diameter

5. GAUGE R&R STUDY:

The purpose of Gauge R&R study is to ensure that the measurement system is statistically sound. Gauge repeatability and reproducibility studies shows that how much of the observed process variation is due to measurement system variation. The sample size was 20 and two readings were taken on each sample, thereby making a total of forty readings as shown in table 3. The instrument used for measuring spring diameter is Screw Gauge.

Table 3: Minitab Data Sheet of Spring Diameter for Gauge R&R Study

Sequence No.	Operation Sequence no.	Operator	Trial	Part No.	Readings (Diameter, mm)
1	1	1	1	3	.94
2	2	1	1	6	.97
3	3	1	1	9	.96

Sequence No.	Operation Sequence no.	Operator	Trial	Part No.	Readings (Diameter, mm)
4	4	1	1	1	.99
5	5	1	1	4	.93
6	6	1	1	7	1
7	7	1	1	8	.94
8	8	1	1	10	.96
9	9	1	1	2	1.01
10	10	1	1	5	.95
11	1	1	2	6	.96
12	2	1	2	1	.93
13	3	1	2	3	.97
14	4	1	2	9	.94
15	5	1	2	2	1.01
16	6	1	2	8	.99
17	7	1	2	10	.94
18	8	1	2	4	.97
19	9	1	2	7	.95
20	10	1	2	5	1
21	1	2	1	8	1.02
22	2	2	1	6	.94
23	3	2	1	2	.97
24	4	2	1	1	.99
25	5	2	1	5	.98
26	6	2	1	3	.93
27	7	2	1	10	.94
28	8	2	1	7	.96
29	9	2	1	4	1.01
30	10	2	1	9	.97
31	1	2	2	4	.98
32	2	2	2	9	.94
33	3	2	2	7	1.01
34	4	2	2	1	.99
35	5	2	2	10	1.02
36	6	2	2	5	.96
37	7	2	2	3	.95
38	8	2	2	8	.94
39	9	2	2	2	0.97
40	10	2	2	6	0.98

Result of Gauge R&R are shown in table 4, Repeatability and Reproducibility came out to be 25.60 and 0.00 percent which put the percentage study variation at 25.60 percent which is less than 30 percent indicating that Screw Gauge was correct

Table 4: Result of Gauge R&R (Spring Diameter)

		Study Var	% Study Var
Source	**Std Dev**	**(6* SD)**	**(%SD)**
Total gauge	0.0271712	.163027	25.60
Repeatability	0.0271712	.163027	25.60
Reproducibility	0.0000000	0.0000000	0.00
Part to Part	0.0024468	0.014681	98.97
Total Variation	0.0272812	0.16368	100.00

6. ANALYSIS PHASE:

In this phase, an action plan is created to close the ‗gap ‘between how things currently work and how the organization would like them to work in order to meet the goals for a particular product or service.

So, the first Rivet height and Riveting assembly process are checked and it is Stage 1.

Stage 1- For this the tool selected in Modified Component Search. This tool is used when the problem is on an assembled product & when it is disassembled, some parts will get damaged. It was selected because Rivet pin will get damaged during disassembly and that component was replaced with new pin for the First trial and Second trial run.

- BOB & 1WOW sample was collected based on Attribute Index.
- Both BOB & WOW assemblies were disassembled for two times and response is as below in table 5.

Table 5: Modified Component Search Response Table

	GOOD(BOB)	BAD(WOW)
Initial Value	1	5
First Disassembly and Reassembly	1	4
Second Disassembly and Reassembly	2	4

Stage 2- After the conclusion of Stage, three components are left that might be causing problem.

In stage 3, one by one component is disassembled from Good and is assembled in the bad and the response is taken as shown in table 6, 7 and 8. List of suspected components are

1) Hook – A (A-R+, A+R-)

2) WAHSER – B (B-R+, B+R-)

3) HOOK BASE PLATE – C (C-R+, C+R-)

Table 6: Response for Hook (A-R+, A+R-)

Good Assembly(–)	Response	Bad Assembly(+)	Response
A-R+	1	A+R–	4

Table 7: Response for washer (B-R+, B+R-)

Good Assembly(–)	Response	Bad Assembly(+)	Response
B-R+	5	B+R–	1

Table 8: Response for Hook Base Plate (C-R+, C+R-)

Good Assembly(–)	Response	Bad Assembly(+)	Response
C-R+	1	C+R–	5

Stage 3- In this stage validation of the results obtained from stage 2 is done. The component identified i.e. Washer has been swapped to the original assemblies and checked for complete reversal as a part of validation.

Table 9: Initial Assembly Response

	Good (BOB)	Bad (WOW)
Initial Value	1	4

Specification of Washer: 1.00 mm & Tolerance: +/-0.25 mm

Conclusions based on Paired Comparison

- From the response , it can be definitely concluded that Washer more than 1.02mm diameter is creating the problem.
- The washer should be less than .95mm and washer tolerance should also be considered for revision.
- Considering Washer Thickness as the response Multi Variant Analysis for the 10 Cavity Mould Tool was conducted.

Cavity to Cavity variation is found to be more than part to part, so the corrective action is required for the cavities**.**

7. RESULTS APPRAISAL:

Initially before the implementation of Six Sigma company was having the high rejection rates and the total cost of poor quality per month is Rs 1, 20,000. But after the implementation of Six Sigma DMAIC methodology it has been reduced to a great extent as the rejection due to tightness of hook is also reduced. This is significant saving

Before Improvement,

Cost of Poor Quality = Rs 1, 20,000 per month

Rejections per month = 300 per month on average

Cost of poor quality per rejection = Rs 400 per rejection

After Improvement,

Rejections per month = 40 per month (reducing)

Cost of poor quality per rejection = Rs 16,000 per month

Savings in cost after improvement = Rs (1, 20,000 – 16000) = Rs 1, 04,000

8. CONCLUSION

It can be concluded that Six Sigma is not only a strategic tool, but it can be used as a process improvement tool as well. In present work, an effort has been made to implement Six Sigma on a small hood latch lock manufacturing industry. The results have shown an impressive reduction in rejection rates. The main reason identified for the rejection is washer thickness. After the application of paired comparison and multi vary analysis, it has been found that the thickness of washer is varying from cavity to cavity which is causing problem. During the improvement phase, the tolerance of the washer thickness has been revised from 1mm +/-0.25mm to 0.90mm -0.00/ +0.05mm. And accordingly the mould has been corrected at the manufacturer‘s place. After the improvement phase, the results have shown a high improvement and reduce the cost of poor quality from Rs 1, 20,000 per month to Rs 16,000 per month making the savings of Rs 1, 04,000 per month which is great achievement and also reduces rejection rate to a high percentage. There is also intangible savings such as reduction in consumer complaints and inspection is avoided during assembly. So with the application of Six Sigma, rejection rates have been reduced to all time low. So, this case study clearly challenges the saying that Six Sigma has the domain of only large companies**.**

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