Process Optimization by using Lean Manufacturing Technique (Six Sigma) – A Case Study in Manufacturing Industry

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Abstract- Aligning Lean manufacturing by applying six sigma in manufacturing industries gives a upper hand for the organization to reduce cost due to scrap & non value adding activities. Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects in any process – from manufacturing to transactional and from product to service. The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects. This is accomplished through the use of Six Sigma sub-methodologies: DMAIC.The Six Sigma DMAIC process (defines, measure, analyze, improve, control) is an improvement system for existing processes falling below specification and looking for continual improvement. It can also be employed if a current process requires more than just incremental improvement. This paper includes a case study on Six Sigma optimization of thinner consumption. The optimization is carried out using six sigma tool without affecting the quality parameter.

Keywords – Six Sigma, process improvement, DMAIC, continual improvement

I. INTRODUCTION

The roots of Six Sigma as a measurement standard can be traced back to Carl Frederick Gauss (1777-1855) who introduced the concept of the normal curve. Six Sigma as a measurement standard in product variation can be traced back to the 1920′s when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction. Many measurement standards (Cpk, Zero Defects, etc.) later came on the scene but credit for coining the term "Six Sigma" goes to a Motorola engineer named Bill Smith. Six Sigma helped Motorola realize powerful bottom-line results in their organization – in fact, they documented more than $16 Billion in savings as a result of our Six Sigma efforts.
Six Sigma has evolved over time. Six Sigma can be seen as: a vision; a philosophy; a symbol; a metric; a goal; a methodology." uses additional, more advanced data analysis tools, focuses on customer concerns, and uses project management tools and methodology.
He summarized the six sigma management method as follows:
Six Sigma = TQM + Stronger Customer Focus + Additional Data Analysis Tools + Financial Results + Project Management

II. UNDERSTANDING SIX SIGMA

Six sigma is a systematic, data-driven approach using the define, measure, analysis, improve, and control (DMAIC) process and utilizing design for six sigma method. The fundamental principle of six sigma is to 'take an organization to an improved level of sigma capability through the rigorous application of statistical tools and techniques' (Antony et al., 2003). It generally applies to problems common to production. From the statistical point of view, the term six sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% where sigma is a term used to represent the variation about the process average. (Antony and Banuelas,2002).

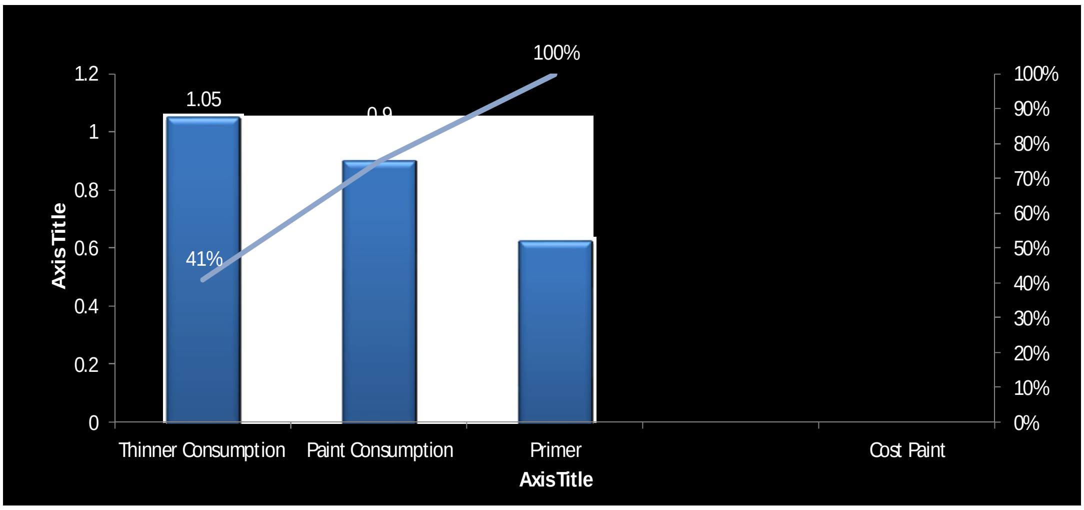
III. DMAIC PROCESS

DMAIC is a closed-loop process that eliminates Unproductive steps, often focuses on new measurements, and applies technology for continuous improvement. Table 1 presents the key steps of six sigma using DMAIC process.

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
Improve : 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

IV. CASE STUDY UNDER OBSERVATION

To reduce the thinner consumption / Engine using Six Sigma Optimization Technique.



As thinner Consumption is high as shown it is selected for optimizing.

Tools Used:

1) Full Factorial

Design Parameters identified for Optimization
A) Thinner Pump Pressure
B) Air Pressure

1st Setting Levels for Design Parameters			
Sr. No	Parameter	(-Setting)	(+Setting)
A	Thinner Pump Pressure	2 Bar	1.5 Bar
B	Air Pressure	4 Bar	4 Bar

Process parameter optimization to reduce thinner Consumption / Engine.

DOE Technique / Tool Used:

- Full Factorial

Quality Parameter is Dry film thickness
(Spec.70-130 micron).

Calculating the D/d ratio for the below reading :

Test	- Setting 2	+ Setting
1st Run	79.4	78.4
2nd Run	95.2	83
3rd Run	106.8	111.8
Median	95.2	83
Range	27.4	33.4
D (Difference Between Two Medians)	12.2	
d = Average of Two Ranges	30.4	
D/d	0.4	

Conclusion: Hence D/d is 0.4 (< 1.5) so there is no difference in Quality

Identify new Settings (General Thumb rule, is increase by at-least 15% from the current condition)

2nd Setting Levels for Design Parameters			
Sr. No	Parameter	(-Setting)	(+Setting)
A	Thinner Pump Pressure	1.5 Bar	1 Bar
B	Air Pressure	4 Bar	4 Bar

Test	- Setting	+ Setting
1st Run	78.4	103.60
2nd Run	83	107.00
3rd Run	111.8	126.40
Median	83	107.00
Range	33.4	22.8
D (Difference Between Two Medians)	24	
d = Average of Two Ranges	28.1	
D/d	0.85	

Conclusion: Hence D/d is 0.85(< 1.5) so there is no difference in Quality
Identify new Settings

3rd Setting Levels for Design Parameters			
Sr. No	Parameter	(-Setting)	(+Setting)
A	Thinner Pump Pressure	1 Bar	0.75 Bar
B	Air Pressure	4 Bar	4 Bar

Test	- Setting	+ Setting
1st Run	103.60	78.2
2nd Run	107.00	110.8
3rd Run	126.40	177.6
Median	107.00	110.8
Range	22.8	99.4
D (Difference Between Two Medians)	3.8	
d = Average of Two Ranges	61.1	
D/d	0.06	

Conclusion: Hence D/d is 0.06 so there is no difference in Quality.
Identify new Settings

4th Setting Levels for Design Parameters			
Sr. No	Parameter	(-Setting)	(+Setting)
A	Thinner Pump Pressure	0.5 Bar	0.25 Bar
B	Air Pressure	4 Bar	4 Bar

Test	- Setting	+ Setting
1st Run	93.8	96
2nd Run	104.8	112.6
3rd Run	120.4	120.6
Median	104.8	112.6
Range	26.6	24.6
D (Difference Between Two Medians)	7.8	
d = Average of Two Ranges	25.6	
D/d	0.36	

Conclusion: Hence D/d is 0.36 so there is no difference in Quality. Identify new Settings

5^{th} **Setting Levels for Design Parameters**			
Sr. No	Parameter	(-Setting)	(+Setting)
A	Thinner Pump Pressure	1.5 Bar	0.75 Bar
B	Air Pressure	3.5 Bar	3 Bar

Test	- Setting	+ Setting
1st Run	98	68.5
2nd Run	103	74.2
3rd Run	106	94.6
Median	103	74.2
Range	8	26.1
D (Difference Between Two Medians)	28.8	
d = Average of Two Ranges	17.05	

Conclusion: Hence D/d is 1.69 so there is difference in Quality.
To find out which is the only important parameter Responsible for difference in Quality. We Plot the Factorial table given below:

Median(+)	74.2
Median(-)	103
Average of Medians	88.6
d	17.05
1.45*d	24.72
1.45*d (after rounding off to the same decimal place as data. Always round off to higher number)	25.00
UDL(+) = Median(+) + 1.45*d	99.2
LDL(+) = Median(+) – 1.45*d	49.2
UDL(-) = Median(-) + 1.45*d	128
LDL(-) = Median(-) – 1.45*d	78

FACTORIAL TABLE IS BELOW :

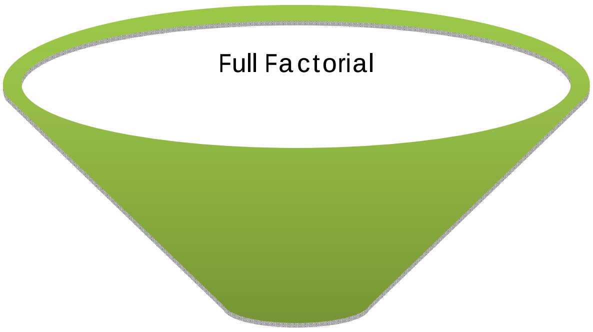
A*B	A	B	Response	Median
+	-	-	98 , 103 , 106	103
-	+	-	85, 85	85
-	-	+	80 , 80	80
+	+	+	68.5 , 74.2 , 94.6	74.2
12.20	23.80	33.80		85.55

Calculating the Optimum Setting for Thinner & Air Pressure by using Minitab

102.9775	0.5	1	1.5	2	2.5	3	3.5	4
0.25	57	60	62	65	68	70	72.99625	75.6625
0.5	39	45	52	59	66	72	78.9925	85.725
0.75	20	31	42	53	63	74	84.98875	95.7875
1	2	17	32	46	61	76	90.985	105.85
1.25	-17	2	21	40	59	78	96.98125	115.9125
1.5	-35	-12	11	34	57	80	102.9775	125.975
1.75	-53	-26	1	28	55	82	108.9738	136.0375

Choosing the optimum value from above table : Thinner Pressure : 0.75 Bar. Air Pressure:3.5 Bar

FUNNELING SUMMARY



Design Parameters : 1)Thinner Pressure 2) Air Pressure

Tangible Benefits derived through the project

1	Cost Saving of Rs 14 / Engine . (217 ml/engine)

V. CONCLUSION

Successful implementation and growing organizational interest in six sigma method have been exploding in the last few years. The above case study has applied six sigma tool Optimization of thinner consumption. Understanding the key features, obstacles, and shortcomings of six sigma provides opportunities to practitioners for better implement six sigma projects. This paper has focused on benefits of sigma in manufacturing industry. Application of tool for optimization without affecting quality parameter. The use of statically software to get optimum settings.

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