

Six Sigma DMAIC in Manufacturing Industry: A Literature Review

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ABSTRACT: At present manufacturing industries are extremely impacted by the rapid varying monetary conditions. In this situation manufacturing industries are facing universal competitions due to globalization. High productivity realization is extremely essential issue for the field of manufacture. With the high productivity few other factors are also must be taken into consideration such as variety in product range, customer demands in terms of quantity and quality at a specified time of delivery, global competitors. The most recent and dominant philosophy named six sigma has been initiated to compact with all these requirements. This paper presents a review of six sigma case studies put into practice in manufacturing industries.

KEYWORDS: Six Sigma, Manufacturing, DMAIC, Productivity, Quality

I. INTRODUCTION

Six sigma is believed as a methodology of put into practice of Total quality management. It is a modern approach to constant process enhancement and a Total quality methodology. At present situation business has become more and more spirited and competitive [1]. Six sigma is a quality tool which is initiated to use in many manufacturing industries make every effort to get near perfection. It is a financial improvement strategy for organization [11]. Six sigma is a data driven process which is used in every organization for process improvement and to reduce defect rate. Six sigma principles have been proven true for both industrial as well as service sectors [12]. Six sigma is a bendable system for attain, maximize success in the business. Proven benefits of Six sigma includes

- Improved productivity
- Increased customer retention
- Reduced cycle time
- Product development
- Growth in market- share

Table 1. Defect rates and competitive level of each sigma levels

Sigma level	Defect rates	Competitive level
6	3.4	World class
5	233	Industry average
4	6210	Industry average
3	66807	Industry average
2	308537	Non-competitive

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2.1 DMAIC PROCESS

DMAIC is known as Define-Measure-Analyze-Improve-Control. Their key processes are explained below

Table 2. Phases of DMAIC process

Phase	Key processes
Define	Define the spoken and unspoken requirements of customers
Measure	Measure the practice to convince customer requirement
Analyze	Analyze the defects and their root causes
Improve	Develop a plan to reduce defects
Control	Develop a policy to observe and control the improved process

II. RESEARCH METHODOLOGY

The objective of this study is to find out a range of benefits achieved through use of Six sigma methodology in manufacturing industries such as improved sigma level, reduced defect rates, increase in productivity, improved safety, quality improvement. This is an attempt to show the improvements of Six sigma methodologies in manufacturing industries. The cases have been taken from peer reviewed journals and publications. The learning of the cases is given in the following progression.

- 1 Broad outline of case industries
- 2 Methodology used by case industries
- 3 Tools and techniques used by case industries
- 4 outcomes achieved by case industries

III. BROAD OUTLINE OF CASE INDUSTRIES

Table 3. Broad outline of research papers with title, publication with year, author, and product

Referred name	Title	Journal, Year	Author/Authors	Product
P	A case study of Defects Reduction in a Rubber Gloves Manufacturing Process by Applying Six sigma Principles and DMAIC Problem Solving Methodology [1].	Proceedings of the 2012, International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, July 3-6, 2012, PP. 473-481	Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier, Luis Rocha-Lona	Rubber Gloves
Q	Outcome of Six sigma Implementation- A Case Study of Manufacturing Industry [2].	International Journal of Innovative Research in Science, Engineering and Technology, Volume:2, Issue:8, August 2013, PP.4076-4082	N.Venkatesh, C.Sumangala, Lancy D'souza	Heavy earth hauling equipments
R	Applying Six sigma to manufacturing processes in the food industry to reduce quality cost [3].	Scientific Research and Essays volume: 6(3), 4 february 2011, PP. 580-591	Hsiang-Chin Hung and Ming-Hsien Sung	Small custard buns
S	Safety Management in	Scientific Research	Lateef Ur Rehman	Structural steels,

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	Manufacturing Company : Six sigma Approach [4].	publishing journal, Volume:4, June 2012, PP.400-407	Akteekh-ur-Rehmen	Steel pipes, Galvanizing services
T	Implementation of Six sigma in a Manufacturing Process: A Case study [5].	International Journal of Industrial Engineering, Volume:16(3),2009, PP.172-181	Adan Valles, Jaime Sanchez, Salvador Noriega and Berenice Gomez Nunez	Circuit cartridges for inkjet printers
U	Safety Management in Manufacturing Industry: A Lean Six Sigma Approach [6].	5 th International & 26 th All India Manufacturing Technology, Design and Research Conference, December 12-14, 2014, IIT Guwahati, Assam, India, PP.641-1 to 646-6	P.R.Gajbhiye, A.C Waghmare, R.H.Parikh	Double roller machines
V	An Application of Six sigma in Service sector-A Case study [7].	International journal of Research in Advent Technology, Volume:2, Issue:2, February 2014, PP.1-9	Aditya R. Wankhade, Sunil S.Girde, Pankaj N.Bandabuche	Idea Sim card sales and recharge
W	Defect Control Analysis for Improving Quality and Productivity: An Innovative Six sigma Case Study [8].	International Journal of Quality and Innovation, Volume:1, Issue:3, 2011, PP.259-282	M.Shanmugaraja and M.Nataraj, N.Gunasekaran	Automobile aluminium components
X	Reduction of Welding Defects Using Six sigma Techniques [9].	International Journal of Mechanical Engineering and Robotics Research, Volume:2, Issue:3, July 2013, PP.404-412	Shashank Soni, Ravindra Mohan, Lokesh Bajpal, S K Katare	Saw welding
Y	Process Optimization by Using Lean Manufacturing Technique (Six sigma)- A Case study in Manufacturing Industry [10].	International Journal of Invention in Engineering and Technology, Volume:3, Issue:3, February 2014, PP.98-108	Amol.J.Gangai, G.R.Naik	Process Optimization of Thinner consumption

IV. METHODOLOGY USED BY CASE INDUSTRIES

Table 4. Methodology used by case industries

Name	Methodology	Goal
P	DMAIC	Reduction of leaking gloves defect.
Q	DMAIC	To Improve Financial status, Productivity, Customer satisfaction
R	DMAIC	To decrease the defect rates of Small custard bun
S	DMAIC	Improve accident prevention system
T	DMAIC	Reduction in electrical failures
U	DMAIC	Overcome loss due to safety

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V	DMAIC	To improve sim card sales and recharge
W	DMAIC	Reduce rejection rates
X	DMAIC	Reduction of Welding defects
Y	DMAIC	Process optimization of thinner consumption without affecting quality parameter

V. TOOLS AND TECHNIQUES USED BY CASE INDUSTRIES

Table 5. Tools and techniques used by case industries

Name	Tools and Techniques
P	Define: Project goal, voice of customer, Project boundary, Team members, Expected Benefits Measure: Data collection, Pareto chart Analyze: Process flow chart, Cause and effect diagram Improve: Two way ANNOVA, Boxplot Control: Bar chart
Q	Bar chart, Data collection, T- test
R	Define: Pareto chart Measure: Data collection, Flow diagram Analyze: Fishbone diagram, X-Y matrix Improve: ANOVA test, Remedial actions Control: Pareto chart
S	Define: Bar chart, data collection Measure: Cause and effect diagram Analyze: Bar chart, Cause and effect diagram, pie chart Improve & Control: Suggestions
T	Define: Box diagram of failure rate Measure: Data collection Analyze: Cause and effect matrix, ANOVA, Control charts Improve: Variance test Control: Bar chart
U	Define: PDCASIPOC Measure: Bar chart, Data collection Analyze: Cause and effect diagram, FMEA Improve: Solution, Bar graph Control: Control chart
V	Define: Project charter, Process flow diagram, SIPOC diagram Measure: Data collection plan, Bar chart Analyze: Voice of customer, Pareto chart, Cause and effect diagram, FMEA analysis Improve & control: Implementation of recommendation of experiment
W	Define: Scope definition Measure: Data collection Analyze: Cause and effect diagram

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	Improve: Taguchi's DOE, ANOVA Control: Bar chart
X	Define: Project team charter, SIPOC, Voice of customer, QFD Measure: CTQ tree, Process mapping diagram Analyze: Pareto analysis, Why-why analysis, cause and effect, brain storming Improve: Final action for validation method Control: Periodic reviews
Y	Define: Process mapping Measure: Data collection Analyze: Cause of defects Improve: Developed alternatives Control: Control process variations

VI. OUTCOMES ACHIEVED BY CASE INDUSTRIES

Table 6. Outcomes achieved by case industries

Name	Outcomes
P	Reduction of 50% of leaking gloves was achieved Defects per million opportunities reduced from 195,095 – 83,750 Sigma level improved from 2.4-2.9
Q	Improved financial status, Productivity, Customer satisfaction
R	Defects rate reduced from 0.45% -0.141%
S	Reduced safety hazards
T	Sigma level gained 0.37 Elimination of 1.88% of non conforming units or 18,788 PPM;s
U	Sigma level improved from 4.64-4.81
V	Sigma level increased from 4.1 – 5.5
W	Rejection rates reduced to 4.8% from 17.22%
X	Reduced possibility of failure Reduced costs of poor quality
Y	Cost saving of Rs 14/Engine (217 ml/Engine)

VII. CONCLUSION

From the above study conclude that Six sigma methodology implemented in manufacturing industries resulted in increase in sigma level, reduced defects, improved productivity, improved safety working environment, reduced safety hazards, improved customer satisfaction. In a developing country like India six sigma is a power full tool which can be initiated in all organizations to improve financial status, growth of the firm. Tools like Lean manufacturing, Triz also can be integrated with six sigma methodology to achieve best results.

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