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**A Review: Six Sigma Implementation Practices in Manufacturing Units
and Benefits Derived**

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Abstract

For global competitiveness Indian industries need breakthrough improvement strategy like Six Sigma to be implemented. It is that improvement strategy by which an industry can improve its base line capability and can gain operational excellence. Six Sigma can help any industry to increase its efficiency and effectiveness by which an industry can gain profit, market share, customer satisfaction and other advantages related with it. Six Sigma methodology can be effectively applicable to any industries. This paper discusses about tools and techniques of Six Sigma applied by different manufacturing units like automobile, rubber, electrical, solar cell etc. in order to achieve business excellence. It also discusses about benefits derived by application of Six Sigma.

Keywords: Six Sigma, DMAIC, Manufacturing.

Introduction

Six Sigma: Concept

Six Sigma was a revolutionary concept when it first emerged in 1980s. It took a while before it caught on, like any other revolutionary concept. Gradually it had become one of the top concept by which companies were able to achieve productivity, profitability, quality and efficiency while improving customer satisfaction, which leads to increased sales and revenue for the company. For global competitiveness and operational excellence, industries need improvement in both productivity and profitability. For that they are using different improvement measures like Toyota Production System, Kaizen, Quality Circle, Pokayoke, Lean manufacturing etc. are a few well-known measures. Statistical Quality Control (SQC), Total Quality Management (TQM), ISO certification etc. has contributed towards achieve the business goals and objectives. All these techniques are capable of achieving desired results but problem occurs with their implementation and longtime results. So the breakthrough strategy which can give multidirectional benefits in short time. It can be achieved by proven breakthrough strategy called Six Sigma.

Six Sigma: Historical Background

Motorola invented the Six Sigma quality improvement process in 1986. Six Sigma provided a common worldwide language for measuring quality

and became a global standard. (Source: www.motorola.com). It is developed by Bill Smith during 1987-1992 at Motorola, later it was adopted by Allied Signals (now Honeywell) (1992-1996) and General Electric, where it was initiated by Jack Welch [20]. Motorola, Honeywell and General Electric has gained profit from Six Sigma adoption and implementation, made other big organizations of the world to adopt methodology in 1990s to grab beneficial results.

With the passage of time Six Sigma has undergone many changes and improvement, also its implementation from manufacturing industries to service industries as well. Six Sigma can be applicable to any product, process or transactions. It can also be applied business operations such as Research & Development (R&D), sales and marketing, on time delivery process, administration and other areas that directly affects the customers. It is a project by project improvement approach which consists of analysis of quantitative data by using statistical tools and techniques. It is a highly data driven approach. Because breakthrough improvements and profits are associated with it, it has taken an attention from academics and practitioners worldwide.

Six Sigma: Definition

Six Sigma is defined in several ways by different experts. Tomkins (1997) defined Six Sigma as a programme aimed at the near elimination of defects

from every products, process and transactions. Harry (1998) defined Six Sigma as a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality.

Six Sigma is a business system with many statistical aspects, and it naturally fits business systems of most companies, it is an improvement drive which has the ability to introduce a common metric of customer-perceived quality which should be applicable to any size and type of organization[16]. Six Sigma is a business strategy that focuses on improving customer requirements understanding, business systems, productivity and financial performance[21].

Six Sigma besides being a measure of performance and process variability is also a management philosophy and strategy that allows organizations to achieve lower cost, as well as a problem solving and improvement methodology that can be applied to every type of process to eliminate the root cause of defects[22]. Six Sigma is one such technique available to bring the breakthrough improvements almost in every sector through overall operation excellence[9].

The origin of Six Sigma comes from statistics and statisticians and deliberates the Six Sigma methodology from a statistical, probabilistic and quantitative point of view. 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%. If an organization is operating at three Sigma level for quality control, this is taken as achieving a success rate of 93% or 66,800 defects per million opportunities. Therefore, the Six Sigma method is a very rigorous quality control concept where several organizations still performs at three Sigma level[23].

Role of six sigma in manufacturing units

After the World War 2 there was a great economic depression in under developed as well as developed countries all over world. During industrial revolution each and every organization in the world was trying to improve their capabilities in every dimension in order to improve their business and to gain profit. Due to exploration to global market, now a days it is essential to have business and operational excellence for any organization to be compatible in global market. It can be achieved by providing quality products according to customer requirement at lower cost which can help to win glory in business. Six Sigma is a breakthrough improvement strategy which can improve bottom-line of business.

It is very vital for manufacturing unit to employ Six Sigma methodologies for defects free production and be globally cost effective[24].

It does not matter what type or size of business Six Sigma methodology is applied to, no matter whether it is a 300 employee company or a 10 employee family business, Six Sigma will work as long as you follow the process effectively[25]. Six Sigma methodology can be applied to any process, product or transactions. It can also be applied to sectors like manufacturing, services, research and development, transactions, banking etc.

Six Sigma methodology can be effectively applied to small, medium and large enterprises. The Six Sigma strategy works well in billion dollar corporations as well as \$50 million privately held companies. In fact, it has been experienced that the results are usually quicker and more visible in small manufacturing units.

Six Sigma is on focus of almost every industrial sector. The objective of this paper is to provide an overview of Six Sigma and general method followed, tools and techniques used and benefits gained by various manufacturing units selected for study.

General overview of case industries

Industries taken as case studies are manufacturing units of various countries. Manufacturing units such as automobile, rubber, electrical, solar cell manufacturing, die casting etc. are studied in order to analyze which Six Sigma tools and techniques are used to solve problems and benefits derived from it. Table 1 contains index no of case studies which are taken from various research papers, their title, publication year with journal in which they are published with the products they are dealing with. The publish cases considered from a set time frame(i.e. 21st century).

Methodology adopted by case industry and benefits derived

Six Sigma methodology has two approaches: 1. DMAIC (D-Define, M-Measure, A-Analyze, I-Improve, C-Control). 2. DMADV (D-Define, M-Measure, A-Analyze, D-Design, V-verify). DMAIC methodology is applicable to existing product or process which is to be improved and DMADV is applicable to new product or process which is to be designed and implemented in such a way that it provides Six Sigma performance. In all case studies discussed here have used DMAIC methodology to improve their existing process.

Table 2 shows the method adopted, objective and benefits derived from it. Six Sigma has been implemented by many industries and most of them

have reaped fruitful benefits from it. The benefits can improve their bottom-line and it can be analyzed by earlier and present status.

Table 1. An Overview of Case Industries

Index No	Title	Journal, Year	Author/Authors	Product
1	Six Sigma based approach to optimize the diffusion process of crystalline silicon solar cell manufacturing	International Journal of Sustainable Energy, 2013	Gura Prasad, S.Saravanan, E.V.Gijo, Sreenivasa Murthy Desari, Raghu Tatachar, Prakash Suratkar	Crystalline silicon solar cell
2	Process improvement through Six Sigma with Beta correction: A case study of manufacturing company	International Journal of Advance Manufacturing Technology, 2014	E.V.Gijo, Johnu Scaria	Automotive part manufacturing
3	Reduction in rework of an Engine Step Bore Depth variation using DMAIC and Six Sigma approach: A case study of engine manufacturing industry	International Journal of Advanced Scientific and Technical Research, 2013	Sunil Dambhare, Siddhant Aphale, Kiran Kakade, Tejas Thote, Uddhava Jawalkar	Engine manufacturing industry
4	Study of feasibility of Six Sigma implementation in a manufacturing industry: A case study	International Journal of Mechanical and Industrial Engineering, 2013	Mehdiuz Zaman, Sujit kumar Pattanayak, Arun Chandra Paul	Welding electrodes
5	Implementation of Six Sigma in a Manufacturing Process: A case study	International Journal of Industrial Engineering, 2009	Adan Valles, Jaime Sanchez, Salvador Noriega, and Berenice Gomez Nunez	Circuit catridges for inkjet printers
6	Relevance of Six Sigma Line of Attack in SMEs: A case study of a die casting manufacturing unit	Journal of Engineering and Technology, 2011	Prabhakar Kaushik	Engine mounting bracket
7	Applying Six Sigma Methodology Based on "DMAIC" tools to reduce production defects in Textile manufacturing	Recent Advances in Industrial and Manufacturing Technologies	Mohammed T. Hayajneh, Omar Bataineh, Rami Al-Tawil	Textile apparels
8	Six Sigma practice for quality improvement: A case study of Indian automobile ancillary unit	IOSR Journal of Mechanical and Civil Engineering, 2012	Dr. Rajeshkumar U. Sambhe	Auto components
9	A case study of defects Reduction in a Rubber Gloves Manufacturing process by applying Six Sigma principles and DMAIC problem solving methodology	International Conference on Industrial Engineering and Operations Management, 2012	Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier, Luis Rocha-Lona	Rubber gloves

Table 2. Methodology, Objective And Benefits

Index no	Method Adopted	Objective	Benefits
1	DMAIC	Optimize the diffusion process of crystalline silicon solar cell manufacturing	An effective gain of 0.9MW reported per annum
2	DMAIC	Improving the first-pass yield of the plunger manufacturing process	Savings of USD 87000 per annum
3	DMAIC	To reduce rework of an engine step bore depth variation	Engine bore rework was reduced from 18% to 2.2% per month
4	DMAIC	Reducing rejection in a welding electrode manufacturing industry	Increase in sigma level from 3.41 to 4.43
5	DMAIC	Reduction in electrical failures in a manufacturing process	Increase in sigma level from 3.2 to 3.35
6	DMAIC	Reduce the rejection rate of the engine mounting bracket(EMB) by reducing defects inherent in the processes	Improvement in sigma level from 1.64 to 5.24
7	DMAIC	To reduce production defects in textile manufacturing	Reduction in the overall quality level from 7.7% to 2%
8	DMAIC	Trimming down defects level which are critical to customer	Reduction in internal PPM from 18909 to 2500 for lighting stock assembly
9	DMAIC	Reduce leaking defects in rubber gloves manufacturing	Improvement of sigma level from 2.4 to 2.9

The tools and techniques used by the case industries

There are many tools and techniques for Six Sigma implementation used in various phases of DMAIC methodology. Table 3 provides information about tool and techniques used by various case industries as a Six Sigma implementation initiative.

Conclusion

From the study done on the manufacturing industries in 21st century we conclude that Six Sigma is a

breakthrough improvement strategy which can help to compete in globalized market. For successful implementation of Six Sigma, parent industry should have to follow correct methodology and steps in order to achieve operational and business excellence. Six Sigma can be effectively applied to any industries without considering type and size of the industry. There is a lot of scope of improvements for all industries by applying and executing this drastic improvement strategy.

Table 3.Tools and Techniques Used By Case Industries

Tools & Techniques	1	2	3	4	5	6	7	8	9
Project Charter	•	•						•	•
Voice of Customer							•		•
Critical to Quality	•	•		•	•		•	•	
SIPOC diagram		•		•		•		•	
Brain storming	•	•		•	•				•
Pareto chart	•			•	•		•	•	•
Process Capability Analysis	•	•		•	•	•		•	
Control chart	•	•	•	•		•		•	
Cause validation	•	•						•	
Cause & Effect diagram	•	•		•		•	•	•	•
Regression analysis	•	•	•	•					
Design of Experiment	•	•				•		•	•
ANOVA	•	•		•	•				•
Process map		•		•		•	•	•	
Multicollinearity		•							

Nested ANOVA		•	•						
Beta correction		•							
Measurement System Analysis			•		•	•			
Gauge R&R			•		•	•			
Fault Tree Analysis			•						
Why-Why Analysis			•						
Tree diagram			•						
Multivariable Analysis Test			•						
Hypothesis testing	•	•	•	•	•				
Correlation analysis			•						
Dot Plot				•					
Cause & Effect Matrix					•				
Two Sample t-test						•			
Prioritization matrix							•		
5s							•		
Failure Mode Effect Analysis								•	
Six Thinking Hat								•	
Box Plot									•

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