Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 5, May-2017

Review of Six Sigma DMAIC Methodology

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Abstract: - *During the past 50 years, more than 69 quality related initiatives have been taken. Statistical Process Control (SPC), Quality Circles (QC), Total Quality Management (TQM), Bench Marking, Quality Management System (QMS), Standard and other such initiatives have created a visible impact in the business world. 'Keep it Simple' formula has always been the basic concept of specialists for performance measurement over the past 70 years in an effort to have the greatest impact on business. In a competitive environment different types of classic tools and metrics have been applied in a different manner.*

Keywords: Six sigma, DMAIC, DOE, Quality management, TQM.

I. INTRODUCTION

Six Sigma is both a philosophy and a methodology that is mainly used to improve quality of product by analysing data with application of statistics method to find out the root cause of quality problems and to implement controls. Although Six Sigma is a method which is first implemented to improve manufacturing but it 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. As an improvement drive, the major advantage of Six Sigma is to introduce a common metric of customer perceived quality, which should be applicable to any size and any type of organization.

II. LITERATURE REVIEW

Mach Pavel et al. (2001) stated that a constant improvement has been accepted as the main objective of companies for all the fields, but this improvement is always keeping SPC and its Seven Ishikawa tools as the base. One of the latest strategies utilized is a six sigma strategy, which works having as the base the quality statistical tools and techniques combined with a well- focused management. There is an important relation between the Seven Ishikawa tools and the six sigma strategy. Six sigma strategies require tools that enables visualize, analyse, and make conclusions about processes, problems, and activities in general. The Seven Ishikawa tools contribute to that purpose, they are important elements that belong to the SPC which is an essential part for the implementation of the six sigma strategy.

Prasad (2002) discussed the six sigma initiatives taken by a bulb manufacturing company to reduce the shell cracking during the manufacturing of bulbs. The company started the initiative with training for champions and black belts. By using DMAIC methodology, the whole process was operating at 4.5 sigma levels, which was earlier at 3.2 sigma level, resulting in significant improvement in the bottom line.

Rowlands et al. (2003) reported the application of design of experiment to spot welding process in order to discover the key process parameters, which affect the tensile strength of welded joints. They have used statistical analysis to identify the process parameters, which affect the mean strength and variability in weld strength. The objectives of the experiment in this study were two-fold. The first objective was to identify the precarious welding process

parameters, which influence the weld strength. The second objective was to identify the process parameters that affect the variability in the weld strength a trade-off in one of the factor levels was observed. This problem has been rectified with the use of Taguchi's loss function analysis. The strength of the weld has been increased by around 25 percent.

Roberts C.M. (2004) presented the report on Bank of America is one of the pioneers in adopting and implementing Six sigma concepts to streamline operations, It has hundreds of Six sigma projects in areas of cross-selling, deposits, and problem resolution. Bank of America reported a 10.4% increase in customer satisfaction and 24% decrease in customer problems after implementing six sigma.

Das (2005) applied the six sigma methodology in the spinning mill which was unable to control the delay in procurement of materials. During implementations of six sigma methodology various KPIV's (key process input variables), CTQs and KVOVs (key process output variables) were identified from the flow of activities. After that PFMEA (potential failure mode and effect analysis) was done which after completion showed an improvement from 38% to 24% in DPMO (defects per million opportunities) level and system performance improved from 62% to 76%.

Thomas et al. (2006) dealt with the application of six sigma in Orangebox Ltd. A SME based in Hengoed, South Wales-a world leader of design and manufacturing of office seating and furniture. The results of the experimental study enabled a change to be made to the parameter settings resulting in a 53% increase in cycles to the onset of failure CTOF. The application of the six sigma approach to a critical to quality (CTO) problem at Orangebox achieved savings around of $60,000 for an initial outlay of less than $5,000 in experimental and project costs.

Arif et al. (2007) applied the integrated approach of six sigma and Theory of Constraints (TOC) in a cotton mill "Priyadarshini Sahakari Soot Girani Ltd." Situated in Maharashtra (India) for improving the manufacturing system performance. The result of the case study indicated that the sigma level substantially improved which resulted in production of premium quality yarn.

Ho Ying-chin et al. (2008) studied critical factors for aircraft maintenance, repair, and overhaul companies during the initial implementation stage of six sigma programs. This is attained by examining 14 key success factors. Employees of an Asian maintenance, repair, and overhaul company are evaluated. Factor analysis is used to identify five key factors that are pertinent to successful completion of Green Belt improvement projects.

Zu Xingxing et al. (2009) investigated how organizational culture influences the implementation of different practices in the recent six sigma approach as well as those associated with traditional total quality management (TQM). Using survey data collected from 226 US manufacturing plants, the relationships between four culture types and 10 TQM/Six sigma practices were examined via the structural equation modelling technique. The results reveal the differential effects of the culture types on the implementation of TQM/Six sigma practices The understanding of the advantage of each culture type should help managers achieve operative implementation of TQM/Six sigma practices from a holistic perspective of both quality management and culture.

Kelly Elizabeth W. et al. (2010) focused on reducing Door-to-balloon Time at a Single Academic Tertiary Care Centre for percutaneous coronary intervention that requires multidisciplinary cooperation, process analysis, and quality improvement methodology. Six sigma methodology was used to reduce D2B times in STEMI (ST-elevation myocardial infarction) patients presenting to a tertiary care centre. Specific steps in STEMI care were determined, time goals were established, and processes were changed to reduce each step's duration. Outcomes were tracked, and timely feedback was given to providers. After process analysis and implementations of improvements, mean D2B times decreased from 128 to 90 minutes. Improvement has been sustained; as of June 2010, the mean D2B was 56 minutes, with 100% of patients meeting the 90-minute window for the year. Six sigma methodology and immediate provider feedback result in significant reductions in D2B times.

Sharma O.P. et al. (2011) contributed to the pharmaceutical industry which is the most regulated of all industries. Regulatory affairs professionals are key players in the product development and as communication link between the industry and agencies such as FDA. Six sigma as a problem solving approach has been used in various fields to provide the fundamentals of variation management and reduction in order to assist in transforming established methodologies in to new and efficient techniques.

Koziolek Sebastian (2012) presented the methodology for evaluating the process of designing and constructing vehicles and machines, which implements Design for six sigma tools. An important purpose of this paper is to determine how defects affects the quality of structure, based on criteria of its agreement. The paper also presents the requirements needed to apply the method and the benefits arising from the use of quality assessment tools. The presented method enables the quality assessment of the design and construction process, which also serves as quality assurance method due to the possibility to avoid potential defects.

Erina J. et al (2013) estimated six sigma implementation in Latvian commercial banks and identify the perceived benefits of its implementation. To achieve the goals, the authors have developed the questionnaire and adapted it for the employees of Latvian commercial banks. The questions are related to Six Sigma implementation and its perceived benefits. The authors have come to the conclusion that there are different attitudes to Six Sigma benefits and critical success factors in the Latvian commercial banking sector.

Chow Timothy et al. (2014) implemented six sigma improvement methodology in academia for improving retention of first-year college students in an academic institution. They communicating the factors involved in student-retention research, improvement strategies, and results attributed to selected courses of action with both internal and external audiences can be daunting. They conclude that our experience in implementing six sigma for improving first-year student-retention process could assist others and serve as a reference to stimulate thinking about finding creative ways to address the student-retention challenge that affects colleges and universities across the nation.

Oko Anthony et al. (2015) addressed the problem of ineffective and inefficient admission process in the higher education institute. To improve the admission process six sigma based DMAIC methodology was used. After implementation test result show high improvement in the process. The improved process will give more values to customers, who are the candidates seeking admission in the college.

Pugna Adrian et al. (2016) illustrated develops a conceptual for predicating success of process improvement projects as a result of knowledge-creation practices employed in the projects. New scales are developed to measure obvious and unstated knowledge creation practices in process improvement. Six sigma methodology implemented to improve the assembly process in an automotive company.

Tagge Edward P. et al. (2017) implemented six improvement methodology in academic children`s hospital to improve operating room efficiency. To achieve the goal the authors formed a multidisciplinary committee and the entire perioperative process was mapped using fishbone diagrams, pareto analysis and other process improvement tools. Results for children`s hospital scheduled main operating room cases are analysed, where the surgical attending followed themselves.

III. DMAIC METHODOLOGY AND TOOLS

Define: Define stage are primarily for data collection which influences the management of the project start and terms of reference. Tools for data collection:-D1: IPO Diagram, D2: SIPOC Diagram, D3: Flow Diagram, D4: CTQ Tree&D5: Project Charter.
Measure: This stage includes selecting the measurement factors to be improved and providing a structure to evaluate current performance as well as assessing, comparing and monitoring subsequent improvements and their capability. The important tools for measurement should include:-M1: Check Sheets, M2: Histograms, M3: Run Charts, M4: Scatter Diagrams, M5: Cause and Effect Diagrams, M6: Pareto Charts, M7: Control Charts, M8: Flow Process Charts&M9: Process Capability Measurement.
Analyze: This stage includes centers in determining the root cause of problems (defects) understanding why defects have taken place as well as comparing and prioritizing opportunities for advance betterment. The important tools for analysis should include:-A1: Process Mapping, A2: Regression Analysis, A3: RU/CS Analysis (Resource Utilisation and Customer Service), A4: SWOT Analysis, A5: PESTLE Analysis (Political, Economic, Social, Technical, Legal and Environmental), A6: The Five Whys, A7: Interrelationship Diagram, A8: Overall Equipment Effectiveness&A9: TRIZ: Innovative Problem Solving.

Improve: This step focuses on the use of experimentation and statistical techniques to generate possible improvements to reduce the amount of quality problems and/or defects. The important tools for improvement should include:-I1: Affinity Diagram, I2: Nominal Group Technique, I3: SMED, I4: Five-S, I5: Mistake Proofing, I6: Value Stream Mapping, I7: Brainstorming, I8: Mind Mapping&I9: Force Field Diagram.
Control: This last stage within the DMAIC process ensures that the improvements are sustained and that ongoing performance is monitored. Process improvements are also documented and institutionalized. The key tools for Control should include:-C1: Gantt Chart, C2: Activity Network Diagram, C3: Radar Chart, C4: PDCA Cycle, C5: Milestone Tracker Diagram&C6: Earned Value Management.

During the initial period of its examination, the Six Sigma program entered only into manufacturing arena. This is due to the reason that the models of Six Sigma contributed by Motorola, GE and Allied Signals are impregnated with manufacturing practices. However, on seeing the tremendous financial gains reaped through the Six Sigma program, the captains of service industries have also been showing interest to implement it in their arena. However, the framework of Six Sigma cannot be adopted in service industries. Rather certain modifications had to be incorporated into the framework of Six Sigma that originated from manufacturing companies (A. Chakrabarty and K. C. Tan 2007). These modifications have been enabling the Six Sigma programs to stand erect on the foundations of service industry essentials. In this context, papers reporting the application of Six Sigma in non-manufacturing area have been frequently appearing in literature. The contributions of some of those papers are described in the following subsections.

Globalization, emergence of new technologies, changing socio-economic profiles of nations and knowledge driven economies has created a scenario where quality in education is beginning to occupy centre stage. Now, the quality is no more a desirable strategy in fact it has become a survival strategy. In such a scenario, technical education institutions require an innovative supporting tool which helps in improving the quality of education system. People in industries from manufacturing to service are witnessing the growth of a strategic continuous improvement concept called Six Sigma. In industry, a company may look defects in its final manufactured products. In engineering education, it can relate those defects as lose of students Six Sigma may provide a philosophy to meet the diverse needs of industry with improved customer satisfaction and in academics an institute can have more involved alumni to help in recruiting more students (Ho et al. 2006). Maleyeff and Kaminsky (2002) have dealt with the introduction of Six Sigma in education. Little (2003) has dealt with the application of Six Sigma in improving the quality of e-learning. He has cited the case of implementing Six Sigma approach in Tata Group, which is one of the largest business organizations of India. Kim et al. (2008) have pointed out the goals of educational institution in disseminating Six Sigma into the society. They have also suggested the curriculum for Six Sigma education. Prabhakar Kaushik (2010) also applied Six Sigma for improving pass percentage of students in an educational institute.

Six Sigma has also found its application in health care sector also. Healthcare services are one of the major active non-manufacturing contexts in which Six Sigma has been adopted, with the majority of papers studying implementation issues in USA. Six Sigma principles and the healthcare sector are very well matched because of the healthcare nature of zero tolerance for mistakes and potential for reducing medical errors. Some papers explain how Six Sigma improves healthcare service quality by reducing medical errors and increasing patient safety. Health care is also an important part of any nation for its development. Parkland Memorial

Hospital is the only public hospital in Dallas County, Texas, and is ranked by U.S. News and World Report as one of "America's Best Hospitals" was limited to doing one project at a time and decided to bring things under control with a process improvement initiative. The hospital hired consultants to observe and analyze how certain things were done in selected departments. Unfortunately, this generated resistance by employees, who viewed the consultants as agents of management who were looking for ways to cut headcount rather than helpful advisors. Based on this experience Mr. Cox and his team (2010) took the approach of deploying iGrafx Six Sigma tools. Mr. Cox and the Six Sigma team educated the Parkland staff to understand that, while each process improvement project would have a different focus, they shared one goal: to help the hospital to efficiently serve more patients. Since iGrafx was cost-effective, very graphical and visual, and integrated with MINITAB, he was able to convince his superiors that iGrafx would be an excellent choice for their process improvement initiative as well. Mr. Cox demonstrated how iGrafx would

help his team analyse, simulate, and reduce cycle times for processes involving service to patients. By reducing cycle times, the hospital could serve more patients, and in turn, generate more revenue, which could further increase the number of patients served. In recent years, finance and credit department are pressured to reduce cash collection cycle time and variation in collection performance to remain competitive. Typical Six Sigma projects in financial institutions include improving accuracy of allocation of cash to reduce bank charges, automatic payments, improving accuracy of reporting, reducing documentary credits defects, reducing check collection defects, and reducing variation in collector performance (Doran, 2003). Bank of America is one of the pioneers in adopting and implementing Six Sigma concepts to streamline operations, attract and retain customers, and create competitiveness over credit unions. It has hundreds of Six Sigma projects in areas of cross-selling, deposits, and problem resolution. Bank of America reported a 10.4% increase in customer satisfaction and 24% decrease in customer problems after implementing Six Sigma (Roberts, C.M., 2004).

IV. CONCLUSION

Six Sigma has already emerged as one of the most effective business strategies in the large organizations, worldwide. Small industries are inherently capable of adopting Six Sigma as breakthrough strategy but they need to show the roadmap. Literature review has also yielded little evidence of any such implementation in a small or medium scale industry. 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. It can also lead us to intangible savings such as reduction in consumer complaints and inspection is avoided during assembly. Application of Six Sigma in Small scale Industries has large scope, but due to lack of knowledge and awareness on latest quality tools and statistical techniques among the management, its implementation is very limited. In this context, application of Six Sigma methodology on one of the chronic problems uncovered the scope of following further study and research in industries. Six Sigma can also be implemented over Small and Medium-Sized Enterprises such as foundries, power looms, rolling mills etc. to improve the productivity level. Application of DMAIC methodology at other areas such as, accounts receivable, shortening development time of the new products, reducing customer complaints etc. and ultimately deploying Six Sigma company-wide. Six Sigma implications can be studied and explored over different service organizations like healthcare, safety care, transportation, traffic management etc.

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