International Journal on Emerging Technologies **7**(2): 39-43(2016)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Productivity Improvement using Lean Six Sigma Methodology: A Comprehensive Review

***Navy Gera**[*] **and Er. Harvinder Lal**[**]*
[*]*M. Tech. Student, Department of Production Engineering, RIET, Phagwara, (Punjab), India*
[**]*Head, Department of Production Engineering, RIET, Phagwara, (Punjab), India*

(Corresponding author: Navy Gera)
(Received 06 August 2016 Accepted 02 September, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The purpose of the work presented in this paper is to capture the current state of Six Sigma as well as to document the current practices of Six Sigma through a systematic literature review. The approach to this research is to answer the questions such as what is Six Sigma?, what are the applications of the Six Sigma?, what are the main enablers and barriers to its application?, and what are the emerging trends? These questions are used to guide the search of papers from various publication databases even if it is expected that existing literature might not be sufficiently developed to translate each question directly into a finding. The literature is then analysed and the major emerging themes are presented. The paper briefly touches on the history of Lean Six Sigma and six sigma project execution methodology which helped to achieve reduction in time & increase of accuracy of that activity. Depending on the purpose every organization will have to find a proper way and a combination of methodologies in its implementation process. The PDCA (Plan–Do–Check-Act) cycle is a well-known fundamental concept of continuous improvement processes, DMAIC (Define-Measure-Analyze-Improve-Control) is a systematic, and fact based approach providing framework of results-oriented project management, DFSS (Design For Six Sigma) is a systematic approach to new products or processes design focusing on development activities.

Keywords: Six Sigma, literature review, DMAIC, DFSS, process improvement

I. INTRODUCTION

The purpose of this paper is therefore to capture the state-of-the-art within the Six Sigma philosophy as well as to document notable development of practices through a systematic literature review. The methodology includes targeting relevant publications databases, searching these using a wide range of keywords and phrases associated
with Six Sigma, and then reviewing each paper identified. The outcome of these reviews was the extraction of a set of key findings, compiled and grouped by topics.

II. SCOPE AND RESEARCH QUESTIONS

To provide a global vision of the subject matter, the scope of this work is not limited in terms of industrial sectors considered but only in terms of the type of sources used, i.e. from journal publications from established databases.
The initial approach to this research was to answer the following questions:
1. What is Six Sigma?
2. What are the applications of the Six Sigma?
3. What are the main enablers and barriers to its application?
4. What are the emerging trends?
The purpose of these questions was to guide the search even if it was expected that existing literature might not be sufficiently developed to translate each question directly into a finding.

III. LITERATURE REVIEW

Alexandra Tenera and Luis Carneiro Pinto (2014) proposes a Lean Six Sigma (LSS) project management improvement model supported by the DMAIC cycle and integrating an enlarged and adapted set of statistical tools, given the nature of the project management main variables and the involved processes. The proposed model was tested in a Portuguese telecommunication company context in which project management processes system are based on Project Management Institute (PMI) standards. The model allowed identifying company's main project management problems, associated causes and the selection of the causes to be first attended [2].

The proposed model also permitted to systematically address the actions and solutions to be implemented in order to keep, in the long run, the continuous improvement of the project management processes in the organization. Ayadi Youssouf *et al.* (2014) research work focuses on the optimization of maintenance for industrial systems by the use of Lean six Sigma bases. Lean Six Sigma is a method of improving the quality and profitability based on mastering statically of process and it is also a management style that based on a highly regulated organization dedicated to managing project. The method is based on five main steps summarized in the acronym (DMAIC): Define Measure, Analyze, Improve and Control. Application of the method on the maintenance processes with using maintenance methods during the five phases of the method will help to reduce costs and losses in order to strive for optimum results in terms of profit and quality [4].

Khaled Mili *et al.* (2014) discusses how to route straddle carriers in port container terminals. This problem is solved in the context of optimizing transport operations. The contribution of the work lies in the formulation and subsequent development of a Six Sigma Approach solution for the problem. Generating and prioritizing the critical Six Sigma transportation plans, however, are real challenges in practice. This study aims to develop a novel approach based on a combined ANP and DEMATEL technique to help container terminals determine critical Six Sigma transportation plans. An empirical case study is used to explore the effectiveness of the proposed approach [8].

Dyah Diwasasri Ratnaningtya and Kridanto Surendro (2013) studies reveals that Six Sigma could be used for reducing information variance in healthcare, especially information that used in Hospital Information System. Information quality is a key element to determine the level of healthcare in hospital. By the improvement of information quality, the quality of healthcare would improve to support the patient's satisfaction. A method used for information quality improvement is Six Sigma [5].

The possibilities and limitations of these two approaches on Tolerance Engineering are discussed in this paper. The case describes cross-collaborative improvement work within industry on tolerance and variation management which is similar to work model called closed loop tolerance engineering (CLTE).

Maha Yusr *et al.* (2012) studies reveals attempts to figure out the relationship between Six Sigma, innovation performance, and examine the mediating role of AC in the relationship matrix. A questionnaire was used to collect the data from the manufacturing companies in Malaysia and Partial Least Square (PLS) techniques were adopted to analyze the data obtained. Based on the literature review, the conceptual framework of this study was introduced. The hypotheses were tested and supported through the findings [9].

Abbas Saghaei *et al.* (2012) presented real case which illustrates the results of applying model upon the industrial production of electronic sets. The quality level measurement of a given process is essential to some phases of six sigma methodology. So far, different indicators have been applied to estimate the capabilities of a process such as classic yield, defect per unit, sigma quality level and rolled throughput yield. However, the examination of the efficiency of total processes in a certain organization is a recent study undertaken. The proposed approach called Enhanced Rolled Throughput Yield (ERTY), unlike other methods, pays particular attention to such factors as the difference between scrap and rework Cycles. The cost of scrap and rework and the sequence of stages. Moreover, the proposed approach is able to cover all previous methods [1].

Sudi Apak *et al.* (2012) research work was an initiative to implement the six sigma methodology in a Hydrogen power plant with the aim of encouraging governments to support the use of renewable energy i.e. hydrogen energy. The aim of research work is to assemble public and private sector officials in an international strategic planning process to advance the efficient development of a hydrogen economy infrastructure and to understand six sigma methodology and its contribution to energy efficiency [14].

Jonnya and Jessica Christyanti (2012) have done research in Indonesia in which many housing constructors are using asbestos as roofing which is partly supplied by PT BBI among many other suppliers. Before the initiative was conducted, the sigma level was at 4.91 sigma with defects per million (DPMO) level at 200 units. By implementing six sigma methodologies, the team found that this condition was mainly caused by side flat as its dominant defect type due to speeding up the curing time without simultaneously increasing its temperature. To solve this problem, the team has proposed that the company should increase its temperature up to 350°C by DOE (Design of Experiment) if it needs to speed up the curing time from normally 5 hours to 4 hours. As the result, the quality figure was better with improved sigma level to 5.02 sigma and DPMO level at 180 [7].

This result might not be significant because there were still many other defect types found in the product that should be followed up by continuous improvement in the company. Swink and Jacobs (2012) assesses the operational impacts of Six Sigma program adoptions through an event study methodology, comparing financial data for 200 Six Sigma adopting firms against data for matched firms, which serve as control groups for the analyses. We employ various matching procedures using different combinations of pre-adoption return on assets (ROA), industry, and size as matching criteria. By comparing performance outcomes across a hierarchy of operating metrics, we establish a pattern of Six Sigma adoption effects that provides strong evidence of a positive impact on ROA. Interestingly, we find that the performance impact of Six Sigma adoption is negatively correlated to the firm's quality system maturity (indicated by prior ISO 9000 certification). Further analyses of manufacturing and service firms reveals that Six Sigma benefits are significantly correlated with intensity in manufacturing, and with financial performance before adoption in services. We discuss the implications of these findings for practice and for future research [15].

Scott M. Shafer and Sara B. Moeller (2012) investigate the impact of adopting Six Sigma on corporate performance. Although there is a fairly large and growing body of anecdotal evidence associated with the benefits of implementing Six Sigma, there is very little systematic and rigorous research investigating these benefits. This research extends previous research in several important ways including utilizing a sample of 84 Six Sigma firms that represent a wide variety of industries and firm characteristics, utilizing rigorously constructed performance over a ten year period. To carry out this investigation, the event study methodology is employed. Benefits in terms of improved asset efficiency were not observed. Finally, there was no evidence that Six Sigma negatively impacts corporate performance [13].

Rodica Pamfilie *et al.* (2012) demonstrated that organizations can obtain individual and organizational performance by using well trained leaders focused on continuous improvement which use Lean Six Sigma in driving employee synergy. The findings of this paper revealed the key factors needed to create a special framework which can lead the organization to business excellence through personnel improvement. This approach can be used by any organization and has the purpose to develop strategic business objectives and to highlight the importance of personal improvement. The data obtained from the questionnaire are analyzed through the SPSS statistical package software [12].

George S. Easton and Eve D. Rosenzweig (2012) studies the role of individual experience, organizational experience, team leader experience, and experience working together on a team (team familiarity) in the context of improvement teams. To do so, we analyze successful and failed six sigma improvement team projects at a Fortune 500 consumer products manufacturer with multiple business groups. Such improvement project teams focus on deliberate learning. Of the four experience variables we study, we find that team leader experience exhibits the strongest relationship with project success, followed by organizational experience. Further, in contrast to prior-related research on work teams, we find no relationship between individual experience or team familiarity and project success beyond that explained by team leader and organizational experience [6].

R. Gonzalez Falcon *et al.* (2011) have done research work which proposes the application of Six Sigma methodology for improving energy efficiency in a distillation unit of a naphtha reforming plant. The results reproduce the past Energy performance of the unit through multivariate models and show optimal operation mode with an expected savings around 150,000€/year. Although the process may further be improved in optimizing the consumption of the reaction unit [11].

IV. RESEARCH GAPS IN THE EXISTING LITERATURE

(i) Business process management tool is not used to prioritize the product and services of production and maintenance in industrial units.

(i) On-line technique is not easily controlled to check the surface defects and monitor the systems for automation.

(i) Defective parts per million calculations provide good results to know defects in the organization.

(i) Regression and correlation analysis should be done on the system or part, to check the affective combination between them.

(i) Very little work has been reported on the statistical tools and techniques and to find the defects using Pareto charts and scatter diagrams.

(i) Earlier technologies of measuring defects are used again and again for each piece for measurement, so it is time consuming process.

(i) Most of the work regarding six sigma has been focused on automobile, electronics and automation industries. Only a limited amount of research has been reported in open literature dealing with the textile industries, hospitals and civil services.

V. CONCLUSIONS

In recent years there has been a lot of interest in the application of Six Sigma principles. Numerous papers have been presented on this subject substantiating the importance of adopting Six Sigma to improve process performance. This research is carried out to identify the latest trends, various approaches, tools and techniques, benefits and combinations of Six Sigma with other concepts by carrying out a systematic, thematic literature review.

Although there is a considerable amount of publication about Six Sigma and therefore a lot of different points of view, it is possible to identify four interpretations of Six Sigma: a set of statistical tools, an operational philosophy of management, a business culture and an analysis methodology that uses the scientific methods, although the streams are not mutually exclusive but instead, overlapping. The main goals of Six Sigma, however, remain unchanged, i.e. improving efficiency, profitability and capability in the process.

There are a large number of tools and techniques within Six Sigma. The variety of tools, however, often causes confusion as to which tools work best for what circumstance of the businesses. A systematic way to guide the selection of these of tools is desirable. Existing literature also traditionally categorises these Six Sigma tools under DMAIC but classification of tools under other alternative approaches such as DFSS, DCOV or DMADV is lacking. Possible explanation of this is that all these DFSS tools are custom-selected for a particular R&D process, industry and use, so a fixed formulation is not possible beyond a broad categorisation (Watson, 2005) [16].

Another issue, as mentioned before, is to clarify the use of the statistical tools and to understand how the simulation can help in the proactive analysis of the systems. Simulation techniques have been identified as one of the promising ones. The main enabler for Six Sigma implementation is the top management commitment that can promote an effective companywide training to let all the employees be involved in the project. The initial methodology of Six Sigma was focused on process improvement and accordingly DMAIC approach was universally adopted, but as time progressed, the need of implementing Six Sigma at design stage of product (or process) was felt crucial and hence the concept of Design for Six Sigma (DFSS) was developed. Several slightly different variations of the aforementioned approaches are available in the literature.

Despite the increased number of papers discussing the adoption of Six Sigma in the service sector in the last few years, the detailed implementation in Small and Medium Enterprises (SMEs) was not widely reported in the academic literature, with the exception of e.g. Antony *et al* (2005a) and Nonthaleerak & Hendry (2008). The literature also supports the view that by adopting Six Sigma the variability in a process will be reduced. In addition to the direct savings which are achieved by improved quality and reduced scrap, the organisation can also be benefited from the indirect savings such as in lower rework cost, minimum product recalls, low warranty liabilities, higher customer satisfaction and brand loyalty. These findings support the view that despite Six Sigma is considered as a fully developed methodology, further research is needed to establish a more systematic approach to help companies, especially SMEs, embark on Six Sigma projects [3, 10].

Although the general approach is quite well known and largely applied in large manufacturing organisations, further work is required to investigate implementation of Six Sigma in the service sector as well as in smaller companies. The findings and issues have provided new insights to take Six Sigma to the next level. This work also contributes the theoretical platform enabling deeper analyses to be carried out on the highlighted fields. As Six Sigma continues to develop and evolve, this type of work should also carry on.

REFERENCES

[1]. Abbas Saghaei (2012). Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Tehran, Iran vol. **140**, pp 368–373.

[2]. Alexandra Tenera, Luis Carneiro Pinto (2014). UNIDEMI, Mechanical and Industrial Engineering Department, Caparica, 2829-516, Portugal vol.**119**, pp 912-920.

[3]. Antony, J., Kumar, M. and Tiwari, M.K. (2005b). "An application of Six Sigma methodology to reduce the engine-overheating problem in an automotive company", Proceedings of the Institution of Mechanical Engineers, Part B: *Journal of Engineering Manufacture*, Vol. **219** No. 8, pp. 633-46.

[4]. Ayadi Youssouf, Chaib Rachid (2014). Badji Mokhtar university, Annaba laboratory environment and transport engineering. Mentouri university, Roumania, vol. **55** , pp 512 –518.

[5]. Dyah Diwasasri Ratnaningtyas (2013). School of Electrical Engineering and Informatics, Bandung Institute of Technology, Jl. Ganeca 10, Bandung, Indonesia vol. **9**, pp 1166 – 1172

[6]. Easton, S.G, Rosenzweig, E.D (2012). The role of experience in six sigma project success: An empirical analysis of improvement projects, *Journal of Operations Management*, 30, pp 481–493.

[7]. Jonnya and Jessika Christyanti (2012). Universitas Bina Nusantara, Jl. K.H. Syahdan No. 9, Palmerah, Jakarta, 11410, Indonesia vol. **65** pp 306 – 312.

[8]. Khaled Mili (2014). Higher Institute of Business Administration of Gafsa, Jemmel 5020, Tunisia vol.**111**, pp-1195-1205.

[9]. Maha Yusr, (2012). Kolej Maybank, University Utara Malaysia UUM, 06010, Sintok, Kedah, Malaysia vol. **65**, pp 570 – 578.

[10]. Nonthaleerak, P., Hendry, L., (2008).“Exploring the six sigma phenomenon using multiple case study evidence”, *International Journal of Operations & Production Management*, Vol. **28** No. 3, pp. 279-303.

[11]. R. González Falcón (2012). Improving Energy Efficiency in a Naphtha Reforming Plant Using Six Sigma Methodology, *Fuel Processing Technology* 103 (2012), pp 110–116.

[12]. Rodica Pamfiliea, (2012). The Bucharest Academy of Economic Studies, Bucharest, 010374, Romania vol. **58**, pp 187 – 196.

[13]. Scott M. Shafera, Sara B. Moellerb, (2012). Wake Forest University, Schools of Business, Winston-Salem, NC 27109, United States, vol. **30**, pp 521–532.

[14]. Sudi Apak (2012). Beykent University, Istanbul, 34396, Turkey, vol. **41** pp 410 – 417.

[15]. Swink, M., & Jacobs, B. W. (2012). Six Sigma adoption: Operating performance impacts and contextual drivers of success. *Journal of Operations Management*, **30**(6), 437-453.

[16]. Watson, G.H. (2005). “Design for Six Sigma: Innovation for Enhanced Competitiveness”, Goal/QPC.