

Operational Guidelines for Six-Sigma Implementation: Survey of Indian Medium Scale Automotive Industries

Rajeshkumar U. Sambhe

Abstract—Large scale Indian manufacturers started implementing Six Sigma to their supply core to fulfill the endless need of high quality products. As well, they initiated encouraging their suppliers to apply the well-ascertain SS management practice and kept no resource for supplier enterprises, generally small mid-sized enterprises to think for the admittance of Six Sigma as a quality promotion drive. There are many issues to study for requisite changes before the introduction of Six Sigma in auto SMEs. This paper converges on impeding factors while implementing SS drive and also pinpoints the gains achieved through successful implementation. The result of this study suggest some operational guidelines for effective implementation of Six Sigma from evidences acquired through research questionnaire and interviews with industrial professionals, apportioned to assort auto sector mid-sized enterprises (MSEs) in India.

Keywords—Indian automotive SMEs, quality management practices, six sigma imperatives, problems faced in six sigma implementation, benefits, some guidelines for implementation.

I. INTRODUCTION

THE Indian automotive component industry is small in size compared to the world market (INR 740,0000 Millions). Industries have experienced a high growth rate of 27 percent over the period 2001-2006, and are expected to grow at a rate of 13 percent over the period 2006-2014 [1]. Multinational automobile manufacturers like Magna International of Canada, Delphi and Ford of US and some European companies have announced plans to enter in the Indian markets [28]. The overall passenger vehicle market in India is expected to grow from 1.7 million units in 2008 to 2.4 million units by 2013, surpassing the markets in Italy and Spain. By 2012, annual car sales worldwide will increase by about 11 million units per year, with India expected to account for 20 percent of the increase. At that point, India will become the world leader in small-car market growth [2]. This bodes well for the auto component industry as it would enable the collective development of auto component SMEs. This will bring in better technology, skills, new products and an assured market Strategic tie-ups and contract manufacturing is another way forward for SMEs in the auto component industry. Looking forward, it is the best of times for Indian auto component manufacturers. The outlook for the industry is bright and is expected to continue on a high-growth trajectory for the next

10 years [28]. The quality of components made in India has improved significantly in the last decade and about 11 Indian auto component companies have won the Deming prize so far. India is estimated to have the potential to become one of the top five auto component economies by 2025 [1].

As late as October 2006, by when the Micro, Small and Medium Enterprises Development (MSMED) Act came to be legislated, the 'medium' category never had been formally defined; albeit, especially, in certain sub-sectors and regions many dynamic small enterprises had been operating at a much higher level of investment in plant and machinery and market reach [3]. But in accordance with the provision of the Micro, Small & Medium Enterprises Development (MSMED) Act, 2006, the micro, small and medium manufacturing enterprises are defined in terms of investment in plant and machinery. Investment amounts in micro, small, and medium enterprises are less than Rs.2.5million, from Rs. 2.5 million to Rs. 50 million and from Rs.50 million to Rs. 100million. However, as per the definition in industrial statistics depends on the number of employees in tiny, small, medium and large enterprises is defined as those employing less than 10 employees, from 10 to 99, from 100 to 299, and more than 299 employees [4].

The medium scale auto component enterprises which have six sources of information to improve productivity and quality of products: (1) R & D mainly through reverse engineering, (2) suggestion from customers, (3) training of engineers provided by suppliers of machinery, (4) cluster development programme organized by ACMA or assemblers, (5) advice from consultants, and (6) technical and foreign collaboration. Medium enterprises cannot spend enough money to develop their product by themselves. Reverse engineering is common method particularly for exporters to the replacement market If they maintain quality, they may get opportunity to supply to foreign assemblers and component manufacturers as tier one and two suppliers. Suggestion from customers is useful to improve productivity and reduce defect ratio. Engineers of assemblers and large auto component manufacturers visit factories of subcontractors regularly and provide advice to them to control quality in supply chain [5].

The remainder of this paper is structured as follows. Section II presents the literature survey based on quality management practices in Indian SMEs. In addition to, it describes the challenges and opportunities concerning Six Sigma application in brief, Six Sigma methodologies with their applications. Section III describes literature snapshot on SS framework. Section IV explores imperatives for SS drive.

Rajeshkumar Sambhe is Associate Professor in Department of Mechanical Engineering at Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, Maharashtra, India (e-mail:rajesh_sambhe@rediffmail.com).

Section V examines the obstacles while implementing SS methodology in mid-sized auto MSEs and benefits attained after Six Sigma implementation are then further explored in Section VI. Section VII discusses few operational guideposts for effective implementation. Finally, the conclusion to this paper is presented in Section VIII.

II. LITERATURE REVIEW

Manufacturing performance is a concept determining the success of manufacturing process both qualitatively and quantitatively. Competitiveness, presence and improvement of business are directly related to manufacturing performance in manufacturing industries. Hence, performance management must focus primarily on manufacturing performance [6]. Small and medium-sized enterprises (SMEs) play a critical role in economies around the world. To remain competitive, SMEs must be capable of delivering high quality products and services on-time at a reasonable cost. In response to these competitive pressures and customer demand, many SMEs have developed ISO 9001 quality management systems (QMS) [7], [8] also proclaim that many large Indian businesses corporate have adopted one or other form of QMS like ISO, TQM, and Six Sigma to realize improved financial returns. But many small and medium Enterprises (SMES) sought registration to any one recognized QMS either due to external customer pressure or as a helpful business promotion tool. The ISO 9001:2000 improves upon ISO 9000:1994 (and ISO 9001:1994) by introducing certain new aspects and reducing the documentation requirement. ISO 9001:2000 specifies requirements for a quality management system. The role of an organization needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements. As well as, it aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements [27]. Many major Indian companies like TATA, TVS, Rane, Maruti, Mahindra and Mahindra had strong commitment for quality with many of them winning Deming prize and other coveted quality awards. However, very few evidence is available regarding the effective implementation and the benefits reaped by small and medium enterprises (SMES) in India [8].

According to [9], Six Sigma is considered as a quality approach which has proved its abilities to positively affect the organizational performance. It is also pinpointed the key research gaps in literature that the link between SS and small businesses is not well explored in terms of real benefits coming from the implementation of the methodology as well there are no clear and detailed description of the used tools and of the methodology adopted for the successful case studies [10]. In [11], dissected by implementing TQM, companies gained in-depth understanding of the key factors associated with the quality supply chain performance practices in Indian automotive industries. They also showed that TQM in supply chain is important to improve key factors such as quality, delivery and lead time.

Different aspects of competitiveness relating to the Indian auto component sector, sets within a globalised economy with its attendant pressures and constraints. It examines the strategies adopted for quality improvement, cost reduction, investment and competency development and aims to establish the relationship between strategies and the different dimensions of competitiveness [12]. ISO implementation in Indian SME and his survey showed that QMS; ISO certified companies were more concerned by internal reasons like improving processes; productivity or products; services than by external reasons like pressure from customers or imitation of competitors. In addition, it is pointed out that the QMS implementation process had generated more internal benefits than external ones. The findings of the research work also indicate that the SME firms will sustain their quality efforts as continuous improvement [13]. Some studies focus on the problems of Six Sigma in services as being data collection and the scoping of service and sub-processes-related projects [14]. It has explored the inter-firm variations [15] in holding the 'automotive industry specific harmonized QMS standard' ISO/TS-16949 accredit for 466 auto component producers in India. Many quality management practices have been developed, built or strategized to escalate the competitiveness of businesses in the modern world. Statistical Process Control (SPC), ISO 9000, KAIZEN, Total Quality Management (TQM), Benchmarking, Theory of constraints, Business Excellence models and many more quality improvement programs have been adopted and implemented by various large scale manufacturer. Six Sigma is the quality improvement program initiated by Motorola. So, the SMEs have opportunities for higher growth and exports, also through linking with the global supply chains. Many firms have multiple quality accredits; the new additional plants by existing firms are usually set up with more advanced standards. Especially large concerns have successfully tried this breakthrough improvement strategy to get solutions in many of their chronic problems. But small and medium enterprises are still ignorant regarding strengths of this improvement drive, of course there may be few exceptions. The research publications illustrating wide-ranging studies regarding penetration of Six Sigma among Indian industries as a whole are not available so far [16], [17] and so there are many challenges and opportunities concerning Six Sigma application to a core service process based on the difference level of companies scale. The Six Sigma DMAIC methodology is used for fixing problems that currently exist in business process activities. DMAIC has been evolved and has been renamed as lean Six Sigma. DFSS is a strategy for new value creation by the design of new products, services or business processes. New value can be in the form of new products, service business processes or a combination thereof that radically improves performance [18]. To ensure self-financing of a six sigma programme from the beginning, the payback period of initial investments will have to take place within a common budgeting period, usually one year [19], [20] spotlighted that strategy formulation and linkage to operations is a very dynamic process in SMEs. Some studies

also focuses on exclusive benefits of SMEs as effective and open communication channels, low resistance to change, people orientation, employees employing a natural responsibility for quality, company-wide awareness, functional integration and innovativeness [21].

Research evidences shows that small and medium scale Indian manufacturing organizations are lagging in implementation of tools and techniques for quality improvement with regards to recent quality initiative like Six Sigma. As well there are merger research articles found which proclaims the extent Six Sigma which has actually been adopted by medium scale concerns in India. So, there is prerequisite to pinpoint the resisting issues which are milling around and percolate the benefits of implementation to foster SS implementation in medium scale enterprises.

III. SIX SIGMA FRAMEWORK: LITERATURE SNAPSHOT

There are many frameworks proposed by different researcher in combination with other quality initiatives in disparate context. Author also explores [22] the study of the combination of two distinct strategies, Six Sigma and Theory of Constraints (TOC), for improving manufacturing system performance. They examined the possibility of integrating them for improving manufacturing system performance and then apply this integrated approach to a manufacturing company in the Midwestern United States that specializes in the production of axles. Some study also focus and introduce a conceptual framework [9] that discuss the relationship between the two fields of the organizational discipline represented by Six Sigma and innovation from the perspective of the Absorptive Capacity Theory. On examination of the integration of lean principles with Six Sigma methodology as a coherent approach to continuous improvement which provides a conceptual model for their successful integration [23]. Study also examines [24] the integration of Six Sigma and Lean manufacturing to improve the production system performance of manufacturing firm. The integrated framework that offers balanced combination of the speed and variation reduction of power of both Lean and Six Sigma to achieve distinct competitive advantage using a case study at Midwestern United State manufacturing firm. It is spotlighted [25] on Six Sigma Process Improvement Model, where the goal of the process is to improve the overall quality of the system under development. Studies also focus on the guiding principles of the Shainin tools [26] are powerful, and at least, in combination, unique. So, it is proposed for SME's to apply simplified Shainin tools based Six Sigma methodology to achieve the optimal results in quality progress and customer satisfaction.

IV. IMPERATIVES OF SIX SIGMA IMPLEMENTATION IN INDIAN SMES

The Indian auto sector market aiming to capture relatively major proportion of the export market, is heading towards ramping up its manufacturing capacities to the meet the global market demand for the quality supply. The significance which

is drifting for supply-chain management in the global business environment is pushing the giant companies to rely upon the small and medium sized enterprises, for catering to the demand which is prevailing in the global market, in an affordable cost and a better quality. The rising demand for high-quality products and substantial standards of business processes by macro organizations had the scope for SMEs to drive its business in a rapid phase where the scope for Six Sigma had been clearly envisaged. The review results dwelled succeeding imperatives which replicate the complex environment where SMEs are carrying out their business operations. Over a period of time, when these companies face the challenges, it leads them to take a proactive stance for Six Sigma implementation.

A. Demand from Large Customers

As many giant automotive manufacturers started deploying the quality practice of Six Sigma, in their business processes. Some of these large customers are spearheading their suppliers to mandate SS implementation to carry forward the business prospect. It is a logical sequence of actions from the entities to carry the same level of quality standards in their supplies to these macro organizations. Such dependence and the drive for the quality is becoming the boomerang because of the prevailing global competitive conditions.

B. Competitive Imperative

Competition is a trend of business in the global auto component industries. SMEs can address these challenges of competition by heading towards improving the quality of their products and services. The significance of Six Sigma is that it is a customer-driven process, idealizing on the needs of clients and providing mechanisms to take action to suit their requirements. Facing the challenges need to address the competition in a pertinent manner require strategies that certainly differentiate their business process from their competitors. By default, the most of the time quality turns out to be the only differentiating factor for companies. The high demand of quality components and highly capable operational processes has kept no alternative to small-middle sized automanufacturers. So, it is a today's need for auto SME's to initiate Six Sigma as a quality initiative. Failure to meet even one of these imperatives can jeopardize company's well-being and survival. If industries fail to provide the quality products and services, there is a risk losing customers who will opt for one of their competitors.

C. Moral Imperative

SMEs have a much quicker immediacy to customers, So this not only eliminates the complexity of any sorts involved; it also envisage to customers' needs that can be incorporated without prolonged and pompous, but also may support SMEs to have a better level of communication with key customers than large clients. Industries should improve the quality standards of their products to meet to the benchmark practices. SMEs need to drive their business process towards an enhanced approach for quality and the Six Sigma initiative is a very viable option before these organizations.

V. OBSTACLES IN SIX SIGMA IMPLEMENTATION

Next subset delivers the genre of problems faced by different organizations while implementing Six Sigma. The prominence of the embarrassing factors while Six Sigma implementation is measured on a Likert scale from 1 to 5 was provided against each, with score 1 indicates least prominent and score 5 indicates the crucial. From the evident of analysis of data, expensive consultation charges; time constraint in data collection and analysis; lack of human resources are the major bounds, retorted by most of organizations. Lack of financial resources succeeded by lack of knowledge is adjacent exigent factors which are rated high. Difficulty in understanding intricate statistical tools rated in 58% cases supported by improper training or coaching in 52.66% respondents. Work force or union resistance is least imperative stumbling block in implementation. SS is a resource intensive program that picks up consistent commitment of resources in terms of developing the organizational culture, infrastructure and training of employees. In addition, Six Sigma involves extensive data collection and its detailed analysis by Six Sigma team to ascertain the root causes and reveal the necessary solutions for process improvement. But this reads good knowledge and practical skills of application on statistical tools and software's. If the most indicative barriers are conquered, then it is leisure for automotive organization to implement Six Sigma.

VI. EXPEDIENCIES OF SIX SIGMA IMPLEMENTATION

TABLE I
ANALYZING BENEFITS OF SIX SIGMA IMPLEMENTATION

Six Sigma Benefits	Mean	SD
Improved customer satisfaction	4.62	0.56
Reduction in process variability	4.33	0.48
Reduction in cost of poor quality	4.33	0.78
Improved company image	4.29	0.66
Improved work culture	3.53	0.5
Better employee efficiency	3.26	0.45
Increase in productivity	3.11	0.69
Increase in profitability	3.03	0.58
Improved sales promotion	3.03	0.58
Reduction in inspection	2.96	0.72

Table I shows the assorted gain attainment from Six Sigma practice at disparate organizations. Enterprises have been interrogated to rate benefits on a Likert scale of 1 to 5. Consequences of analysis disport that, pre-eminent of Six Sigma methodology with end results, these enterprises too have extracted noteworthy gain through improvement in customer satisfaction, reduction in process variability, reduction in cost of poor quality. Improved company image is a succeeding significant benefit is a natural outcome of the customer satisfaction. Furthermore, improved work culture as well better employee efficiency has facilitated enterprises to improve productivity and both these benefits came out as adjacent to significant benefits. This may get better by promoting reward and incentive based system to improve the morale of employees. Increase in productivity and increase in

profitability got subsequent places. Improved sales promotion and reduction in inspection are the other two consequent but less significant benefits obtained as they may require exploring in deep roots for Six Sigma progress.

VII. SOME GUIDELINES FOR EFFECTIVE SS IMPLEMENTATION

The insight which is gained from these research findings of mid-sized automotive enterprises, following guidelines are being proposed for effective Six Sigma implementation.

- 1) A well-structured 'Training System' should be in place which will give the leverage to the staff to understand the intricacies involved in the implementation. Training scheme ought to be well structured which shall result in saving the huge costs associated with the hiring the expertise and other such relevant costs. The costs associated with knowledge imparting and the training towards the process, can be mitigated by entreating their client base to impart the training to the middle management at their organization and which in turn dressed to be in-house training by trained managers to team members which will educate them on Six Sigma methodology and quality tools. This way the qualification criteria can be attained for the distinct Six Sigma roles.
- 2) The most essential includes statistical analysis of daily routine process data and accordingly correction in requisite processes or tooling for the effective use of DMAIC methodology. To influence this, the Six Sigma team should be fully conversant and structured on the function of tools and software tools. For initiating Six Sigma project, Microsoft Excel can fit for regular data analysis; is tardily accessible and user friendly statistical tool. After successful accomplishment or gain from the project, initiate horizontal deployment for different CTQs', then one can go for investment in special and powerful statistical software tool like Minitab etc. Since software like Minitab centers on the practical facets of extensive statistical tools and renders dynamic tools for analysis of non-normal data and hypothesis testing. Its applicability extends to Design of experiments (DOE), Regressions and Forecasting and advanced statistical applications. So, from attainable IT resource, one can achieve more significant benefits and deliver the Six Sigma success.
- 3) Dedication and determination from the top management will be vital factor which can drive the process of implementing Six Sigma practice in MSEs'. Top Management must be part of Six Sigma and should delve towards its implementation by being the role model for the further down of the work force. They should support the Six Sigma project by individually squandering time in Six Sigma training, speaking and answering questions rising by employees, creating a review mechanism for the progress, and monitoring Six Sigma project progress. The commitment from the Top management; cultural change; effective communication; teamwork and employee training and education are succeeding vital soft factors

which should be in point of fact constituted in the organizational culture to optimize the effectiveness of Six Sigma success.

- 4) Effective communication turns out to be the effective tool to address the issues involved with resistance to Six Sigma and to keep the momentum going uninterrupted for quality initiatives within the organization. An effective communication system is to be developed to address the importance of Six Sigma quality and gain to get achieved from the entire SS activities. This should be implemented to evade off two basic fears at individual levels: fear of change and fear of not measuring up to the new standards. So, the most commonly used communication media are Q & A sessions at managerial level and accordingly workshops and individual meetings with employees.
- 5) An effective Six Sigma organizational infrastructure should be put in place and vital in Six Sigma drive. Competent Managers in terms of experience, training skills cognate to project management and statistical analysis should elite for training. Educated and trained managers through customer support or consulting organizations are the frontline project leaders, facilitating the training, educating of Six Sigma methodology and tools in collaboration of team members on planning and implementation of Six Sigma projects. Team members cum supervisors should be opted depending upon their expertise and abilities to handle organizational processes and their authority on execution of statistical and project management tools and techniques.
- 6) The project selection criterion for the project should be affirmed and succeeding a horizontal deployment of other project should initiate. Each Six Sigma project should be evaluated against the criteria and selected project can possibly create the maximum effectiveness in delivering further levels of customer satisfaction which is the bottom line of any business pedagogy. A well-structured and balanced approach can give the desired output of delivering successful implementation of Six Sigma practice into organizational progress.

VIII.CONCLUSION

As a result of major financial constraints on expensive consultation and available meager human resource in MSEs, highly organized 'Training System' should be designed for successful SS accomplishment. Few competent personnel in terms of experience, training skills cognate to project management and statistical analysis should elite for external training or customer organizational support. These small groups of educated and trained technocrats are the frontline project leaders, facilitating the internal education and training on Six Sigma methodology and common tools in collaboration for planning and implementation of first Six Sigma project. Enterprises can employ Microsoft Excel as a tool for data analysis which is well known and tardily accessible statistical tool. Investment in dedicated Six Sigma software tools which lends cost at initial stages of SS implementation can be excluded till successful accomplishment one SS project. The

study pinpointed that these enterprises too have extracted noteworthy gain through improved customer satisfaction and reduction in cost of poor quality through execution of DMAIC practice. The improved company image is a succeeding significant benefit which is a natural outcome of the customer satisfaction.

Future researches may be carried out corroborate and develop guidelines with integration of other quality management practices for disparate small medium scale auto clusters in India and other part of globe. Extent study and researches is constitutional in this direction to validate the accessible issues to explore categorically in varied business verticals.

REFERENCES

- [1] "Defining the Role of the Government in the Transnationalisation Efforts of the Indian SMEs in the Auto Components Sector", Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, New Delhi, 2008, Published by: IDC (India) Limited, Cyber House, Gurgaon, www.dsir.gov.in/reports/ittp_sme/AutoCompReport.pdf, Last visited 15 March 2011.
- [2] Sehga, V., Ericksen, M. and Sachan, S. (2009), "Revving the Growth Engine India's Automotive Industry Is on a Fast Track", *Management Magazine Strategy+Business*, Booz & Company, USA, http://www.booz.com/media/uploads/Revving_the_Growth_Engine.pdf, Last accessed 01/03/2012.
- [3] Das, K. (2007), "SMEs in India: Issues and Possibilities in Times of Globalization", Chapter 3, "ERIA Research Project Report 2007 No.5, ASEAN SMEs and Globalization", pp. 69-97. Article last accessed 1/03/2012 from; <http://www.eria.org/research/images/pdf/PDF%20No.5/No.5-3-India.pdf>
- [4] (2010), "Buyers guide 2010, the Indian automotive industry," *Automotive Component Manufacturers Association of India (ACMA)*; New Delhi, 2010.
- [5] Uchikawa, S., Roy, S. (2010), "The Development of Auto Component Industry in India", on project entitled "Formal and Informal Employment Growth in Manufacturing in South Asia: India and Bangladesh, Detailed work on India and Bangladesh-Based on case study and survey on limited number of firms", Paper-6, pp. 1-20, <http://www.ihdindia.org/Formal-and-Informal-Employment/Paper-6-The-Development-of-Auto-Component-Industry-in-India.pdf>, last accessed 02/03/2012.
- [6] Akyüz, G. and Kuruüzüm, O. (2011) 'A modeling approach in process industry for improving manufacturing performance', *Int. J. Productivity and Quality Management*, Vol. 7, No. 1, pp.74-89.
- [7] Sousa, P., Altinkilinc, M. and Searcy, C. (2009), "Implementing a Functional ISO 9001 Quality Management System in Small and Medium-Sized Enterprises", *International Journal of Engineering (IJE)*, Volume (3) : Issue (3), pp.220-228.
- [8] Sriram, K. (2010), "QMS Positive Impact for SMEs: An Indian Textile Exporter's Example", *Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9 – 10, 2010*.
- [9] Maha M. Y., Abdul R. O. and Sany S. M. M. (2011) 'Six Sigma and Innovation Performance: A Conceptual Framework Based on the Absorptive Capacity Theory Perspective', *International Journal of Emerging Science*, Vol. 1, No. 3, 307-323.
- [10] Cagnazzo, L. and Taticchi, P. (2010), "Six Sigma for big companies and SMEs: evidences from literature", *WSEAS TRANSACTIONS on Business and Economics*, Issue 4, Volume 7, October 2010, PP.295-310.
- [11] Saad, M., and Patel, B. (2006), "An investigation of supply chain performance measurement in the Indian automotive sector", *Benchmarking: An International Journal*, Vol. 13(½), pp. 36-53.
- [12] Singh, R. K., Garg, S.K. and Deshmukh, S.G. (2007), "Strategy development for competitiveness: a study on Indian auto component sector", *International Journal of Productivity and Performance Management*, Vol. 56 Issue: 4, pp. 285 – 304.
- [13] Bewoor, A.K. and Pawar, M.S. (2010), "Use of Shainin tools for simplifying Six Sigma implementation in QMS/ISO certified

- environment– an Indian SME case study”, *Journal of Engineering Research and Studies*, E-ISSN 0976-7916, Vol. 1, Issue 1, E-journal.
- [14] Shahabuddin, S. (2008) ‘Six Sigma: issues and problems’, *Int. J. Productivity and Quality Management*, Vol. 3, No. 2, pp.145–160.
- [15] Singh, N. (2010), “Adoption of industry-specific quality management system standards: determinants for auto component firms in India”, *International Journal of Productivity and Quality Management*, Volume 5, No. 1 pp.88 – 107.
- [16] Desai, D.A. and Patel, M.B. (2009), “Impact of Six Sigma in a developing economy: analysis on benefits drawn by Indian industries”, *Journal of Industrial Engineering and Management*, ISSN: 2013-0953, Vol. 2(3): pp. 517-538.
- [17] Natarajan, R.N. and Morse, J. (2009) ‘Six Sigma in services – challenges and opportunities’, *Int. J. Productivity and Quality Management*, Vol. 4, Nos. 5/6, pp.658–675.
- [18] Azis, Y. and Osada, H. (2011) ‘An empirical study of new value creation in financial service companies using design for Six Sigma approach’, *Int. J. Productivity and Quality Management*, Vol. 7, No. 1, pp.104–124.
- [19] Godecke Wessel and Peter Burcher (2004), ‘Six sigma for small and medium-sized enterprises’, *The TQM Magazine*, Vol. 16, No. 4, pp. 264-272.
- [20] Gunasekaran, A., Okko, P., Martikainen, T. and Yli-Olli, P. (1996), “Improving productivity and quality in small and medium enterprises: cases and analysis”, *International Small Business Journal*, Vol. 15 No. 1, pp. 59-72
- [21] Ghobadian, A. and Gallea, D. (1997), “TQM and organization size”, *International Journal of Operations & Production Management*, Vol.17, No.2, pp. 121-63.
- [22] Ike Ehie and ChwenSheu, (2005) ‘Integrating six sigma and theory of constraints for continuous improvement: a case study’, *Journal of Manufacturing Technology Management*, Vol. 16 Iss.5, pp.542 – 553.
- [23] M.P.J. Pepper and T.A. Spedding (2010) ‘The evolution of lean Six Sigma’, *International Journal of Quality & Reliability Management*, Vol. 27, Iss. 2, pp.138 – 155.
- [24] Ike C. Ehie and RupySawhney (2005), ‘Integrating Six Sigma and Lean Manufacturing for Process Improvement- A Case Study’, Chapter 36, *Handbook of Industrial and Systems Engineering*, Edited by Adedeji B. Badiru, CRC Press 2005, Pages 36-1–36-12, ISBN: 978-0-8493-2719-3.
- [25] Zenon Chaczko, Essam Rahali and Rizwan Tariq (2007), ‘The Application of Six Sigma to Integration of Computer Based Systems’, *World Academy of Science, Engineering and Technology*, 34, 2007, pp. 332-337.
- [26] Bewoor, A. K. and Pawar, M. S. (2010), “Mapping macro/micro level critical links for integrating Six Sigma DMAIC steps as a part of company's existing QMS: an Indian SME case study”, *International Journal of Six Sigma and Competitive Advantage*, Vol. 6, No. 1-2, pp. 105 – 131.
- [27] http://www.iso.org/iso/catalogue_detail?csnumber=21823, Last accessed 15/11/2015.
- [28] <http://www.dnb.co.in/smes/smes.asp>, “Emerging SMEs of India- Auto Components”, Last accessed 15/11/2015

Rajeshkumar Sambhe is Associate Professor (Mechanical Engineering) in Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India. He is concluded his Doctoral studies from Government College of Engineering Amravati and awarded by Sant Gadge Baba Amravati University, Amravati in Aug 2012. He holds his Bachelor Degree in Mechanical Engineering with University Merit and Master Degree in Production Technology with total 18+ years’ experience. He has published 20+ research papers in international journals and conferences including paper in International Journal of Six Sigma and Competitive Advantage; International Journal of Productivity and Quality Management; and International Journal of Business Excellence.(e-mail:rajesh_sambhe@rediffmail.com).