DOI:10.26524/jms.2013.70

Study on Impact of Lean Six Sigma

Koay Boon Hui and Shahryar Sorooshian
Falculty of Technology, Universiti Malaysia Pahang, Malaysia

ABSTRACT: This paper purpose is to investigate the benefits of Lean Six Sigma to the Malaysian automotive industry. Lean is an approach that seeks to improve flow in the value stream and eliminate waste. It's about doing things quickly. Six Sigma uses a powerful framework (DMAIC) and statistical tools to uncover root causes to understand and reduce variation. It's about doing things right (defect free). As global competition continues to grow, the pressure to improve becomes more and more intense. Thus, a combination of both Lean and Six Sigma is born. This method provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost. Thus, this paper also tries to examine how the Lean Six Sigma can contribute and brings a positive impact to the automotive industry in Malaysia.
Keywords: Lean production, Six sigma, Lean Six Sigma

INTRODUCTION

This paper introduces the fundamental concepts that are necessary to understand and use Lean, Six Sigma (SS) and Lean Six Sigma (LSS) in an organization. These concepts include a definition, history and philosophy of Lean, SS and LSS. For better understanding of the present study, a comprehensive search of previous literature has been undertaken. As such, this paper was organized in the manner to give an overview of literature, discusses the benefits of LLS.

1. LEAN MANUFACTURING (LM)

Lean manufacturing is a management philosophy that aimed to achieve smooth production flow by eliminating waste through a focus on exactly what the customers want, and increase the activities value. It is derived mostly from the Toyota Production System (TPS) which is pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo in the 1950"s [1]. The lean concept evolved as time goes on and from lean production meaning extended to a whole enterprise model and now even to an extended lean enterprise model [2].

Lean operations are also driven by workflow initiated by the "pull" of the customer order. It is aimed at the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management [3]. As a result, "companies have substantially cut lead times, drastically reduced raw material, working-process and finished goods inventories, and effectively increased asset turnover [3]. This philosophy was based on lean principles.
There are three core principles stated by Womack et al. [5] which are identification of value, elimination of waste, and the generation of smooth flow. However, these principles were further expanded by into five principles:

1. *Identifying customer defined value.*
2. *Optimizing the value stream.*
3. *Converting the value flow smoothly by controlling and eliminating wastes.*
4. *Activating the demand pull by synchronizing customer demand and information flow.*
5. *Perfection of all processes and services through elimination of muda or waste.*

There are seven Ohno"s wastes as shown below [5]:

1. *Overproduction: Products and services that are in excess to current customer requirements.*
2. *Wait Time: The time that WIP is not directly related to a customer requirement.*
3. *Transportation: Moving raw materials, product, or information unnecessarily.*
4. *Inventory: Work-in-process (WIP) that is not directly related to a customer requirement.*
5. *Motion: The unnecessary movement by people.*
6. *Overprocessing: Adding value to a process/product the customer would not pay for.*
7. *Defects: Flaws in the WIP, final products, or services that do not meet the customer"s requirements.*

Lean was adopted widely by manufacturing companies in the 1990"s as a rapid problem solving approach and now it is being successfully used in service and transactional environments, including financial services.

2. SIX SIGMA (SS)

The Six Sigma approach was first introduced in 1987 by Motorola, and its purpose was to improve organizational performance by reducing process output variation [6]. Numerous companies have gained substantial benefits from the Six Sigma programme, though not all are successful [7].
The Six Sigma has two meanings in Total Quality Management (TQM). In statistical terms, Six Sigma is a program with a goal of reducing output variation so that no more than 3.4 defect parts per million opportunities [8]. It requires a process to produce 99.99966% of the products or service units to be defect free with an extremely high capability. For example, if 1 million passengers pass through the St. Louis Airport with checked baggage each month, a Six Sigma program for baggage handling will result only 3.4 passengers with misplaced luggage [9].
The second TQM definition of Six Sigma is a program designed to reduce defects to help lower costs, save time, and improve customer satisfaction [9]. This methodology targets the variation in processes, identifies and eliminates the defects or variations to improve

quality and performance of business processes [10]. The methodology employs sophisticated process analysis, data collection, quality management and control and statistical techniques in an integrated framework [11]. The Six Sigma methodology requires a process to produce 99.99966% of the products or service units to be defect free which means that there can only be 3.4 defected units per million. Early in its development, a team at Motorola developed a four-phase process for improving the quality of its products looking at „„Definition,"" „„Analysis,"" „„Optimization,"" and "Control"" [12]. Based on this four-phase process, two additional major processes were developed: the "Define, Measure, Analysis, Improve, and Control"" (DMAIC) [13].

Table 1: DMAIC methodology 9 Modified from work of Kumar & Sosnoski [14], and Heizer & Render [9]

N°	Phase	Key processes	Tools
1.	D– Define	Define the project's purpose, scope, and outputs and then identifies the required process information, keeping in mind the customer's definition quality.	Pareto analysis; Project charter
2.	M– Measure	Measure the process and collects data.	Descriptive statistics; Process capability analysis
3.	A– Analyse	Analyse the data, ensuring repeatability, and reproducibility.	Detailed process map; Fish-bone diagram
4.	I– Improve	Improve by modifying or designing, existing processes and procedures.	Experimentation; New process
5.	C– Control	Control the new process to make sure performance levels are maintained.	Statistical process control

Näslund [15] argued Six Sigma implementation should involves eight characteristics, that are

1. an understanding of project expectations from the shop floor;
2. leadership of top management;
3. disciplined application of DMAIC;
4. fast application of the project (3–6 months);
5. clear definition of results to be reached;
6. supplying of infrastructure to implement improvements;
7. focus on the consumer and the process;
8. focus on the statistical approach to improvement.

3. LEAN SIX SIGMA (LSS)

The Lean Six Sigma is a new concept in improvement approaches [16]. It is defined as the combination of two most powerful improvement methodologies, Lean and Six Sigma [17]. The goal is to boost quality and reduce costs through elimination of waste and variation reduction in the processes [18], by using two important tools namely ―value stream mapping‖ and ―Balanced Score Card‖ [19]. Organizations around the world are reaping the benefits of competitive advantages and reduced costs. Thus, more and more companies are promoting Lean Six Sigma in their processes. The figure 1 shows how LSS followed two completely different paths and converged to become what is now the most accepted methodology namely Lean Six Sigma.

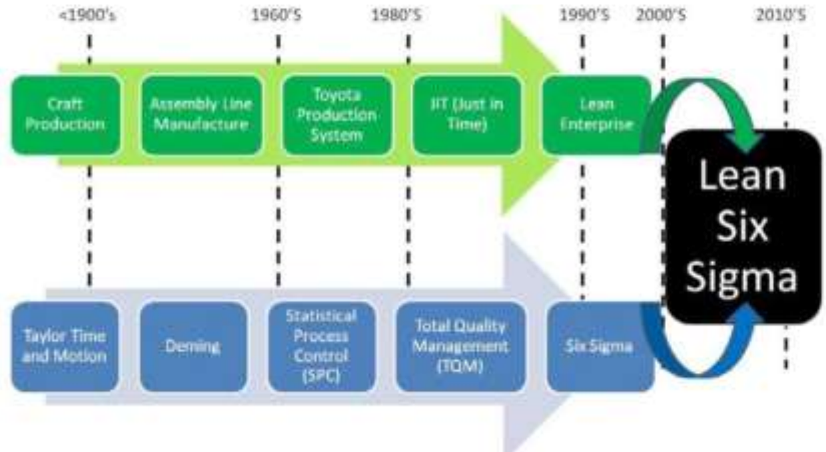

Figure 1.1 Evolutions of Lean Six Sigma [20]

As shown in the Figure 1, both approaches, Six Sigma and Lean existed in parallel and had separate developments for many years. Six Sigma development was driven by the need for quality improvement in manufacturing complex products since there was a high probability of defective final products, while the elimination of waste was the main motive for Lean Manufacturing development [21]. At first the combination of between Six Sigma and Lean was categorized only as theory as there are some cases facing problem in the control phase of Six Sigma DMAIC methodology after applying Lean Manufacturing to remove all the sources of waste during sub optimization of processes [22]. The fusing between lean and Six Sigma have been implemented in isolation, but unfortunately this act cause a conflict of interest and a drain on resources [23]. However, later, researchers realized that actually both concepts were complementary through their experience in process improvement.
Arnheiter and Maleyeff [21] have claimed that Lean Six Sigma organizations would capitalize on the strengths of both Lean and Six Sigma by applying the primary tenets from each approach. Lean would bring integration of its overriding philosophy to optimize the value-adding components of all processes, constant evaluation of the incentive systems in order global optimization to be assured, and optimization of decision-making process to be based on a customer's impact. Scientific decision making using data-driven

methodology that strives to minimize variations of quality characteristics and company-wide introduction of a structured training and education regime would be the major tenets brought by Six Sigma.

There have been attempts to combine the two methodologies under titles such as ―Lean Six Sigma‖. Figure 2 presents the integration of lean and Six Sigma.

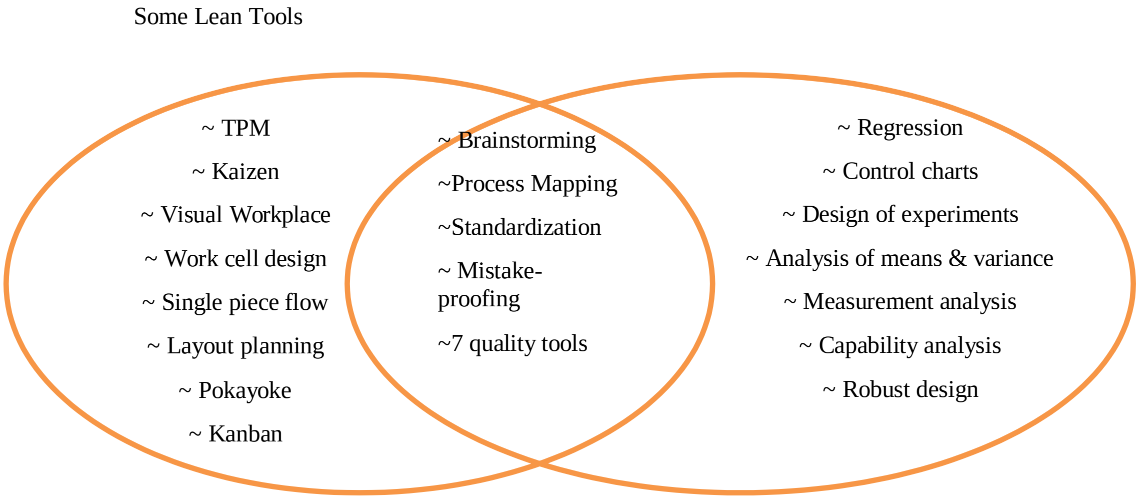

Figure 2: Six Sigma and lean common tools (Modified from work of Antony, Escamilla, and Caine [24], Pepper and Spedding [25], Salah, Rahim, and Carretero [26]).

However, the concepts of lean Six Sigma as an approach to process improvement has yet to fully mature into a specific area of academic research [22]. It can be said that in practice the majority of efforts to fully and comprehensively implement a lean Six Sigma initiative to its full potential have not been realised [23]. This failure to sustain a change towards continuous improvement can be attributed for one, to the lack of commitment from management [27].
If an organization wishes to implement Lean Six Sigma successful, the organization should follow the following lean and Six Sigma principles [21]:

- the organisation must focus on maximising the value-added content in all operations and processes (lean principle)
- the top management must implement a decision-making process that bases every decision on its impact on the customers (lean principle)
- the organisation must constantly evaluate all of its incentive systems to ensure that they result in global optimisation (lean principle)
- the organisation must utilise data-driven methodologies to ensure that all the changes are made based on scientific studies rather than making ad hoc decisions (Six Sigma principle)
- the organisation must utilise methodologies to minimise variations in quality characteristics (Six Sigma principle)
- the organisation must implement a companywide and highly structured education and training programme (Six Sigma principle).

The table 2 clarifies the comparison between Lean and Six Sigma regarding various characteristics.

Table 2: The main differences between Lean and Six Sigma regarding various characteristics (Modified from Bhuiyan et al. [28]; Nave [29])

Characteristic	**Lean**	**Six Sigma**
Origin	Evolution in Toyota	Evolution in Motorola
Objectives	Provide high value to the customer by reducing waste	Product and process improvement; minimisation of variation
Principles	• Use the best practices and processes to improve efficiency • Reduce costs • Speed up the process.	• Keep the number of defects below 3.4 per million opportunities.
View of waste	Non-value adding activities	Variation
Product	Standardized product, preferably with low variety	Manufacturing-, service-, health-care-, government-related product
Demand	Preferably but not limited to high volume	No special requirement
Organization	• Total commitment • Long-term buyer/ supplier relationships	• Specialist hierarchy, • Project-based, • Metric-performance-driven
Human	• Intrinsic	• Extrinsic

resources	• Shop-floor level project initiation • Bottom-up approach	• Top-down selection of improvement initiatives
Focus	• Efficiency • Flow • JIT • Standardization, • Cost and waste reduction	• Customer • stakeholder value • process variation • statistical decision making
Market situation	Stable, high forecast accuracy	No special requirement
Methodology	1. Identify value 2. Optimize value stream 3. Convert flow smoothly 4. Active demand pull 5. Perfection of process	1. Define 2. Measure 3. Analyse 4. Improve 5. Control
Tools and Techniques	• TPM • Kaizen • Visual Workplace • Work cell design • Single piece flow • Layout planning • Pokayoke • Kanban • 5 S • Value stream mapping	• Regression • Statistical process control charts (histograms, normal distribution graphs, flowcharts, etc.) • Design of experiments • Analysis of means & variance • Measurement analysis • Capability analysis • Robust design • Quality management tools (activity network diagrams, affinity diagrams, etc.)
KPI	Value provided to the customer	Number of defects, customer satisfaction

Despite the several success stories associated with the lean concept, it has some weaknesses. First, lack of flexibility of lean concept decrease the ability of the organization to react to the new conditions and circumstances which may cause the lean organization to become very susceptible to the impact of changes [30]. This is due to Lean concept is focus on perfection, there is no space for flexibility, thus, Lean cannot apply in a highly dynamic conditions as it requires a stable platform where scale efficiency can be maximised [31]. Second is failure in application of JIT deliveries may cause congestion in the supply chain, thus lead to delays, pollution, shortage of workers, etc. [27].

To overcome these weaknesses, the lean approach must integrate the use of targeted data to make decisions and also adopt a more scientific approach to quality within the system [25].

On the other hand, Six Sigma also has its own weaknesses. According to Magnusson et al. [32], it is complicated to reach the customer‘s needs and hence increase the customer satisfaction by applying six sigma method. Thus, some companies use voice of the customer tools in their define phase to avoid this problem.

Beside this, Andersson, et al. [31] found that only project with given a certain amount of saving is only allow to start in Six Sigma training project. Moreover, this project usually only involve in the department of the project members which leads to an improvement in the department but also may cause another department to experience deterioration due to change. As a result, SS is sometimes accused for not having a system view.

4. BENEFITS of LSS

Lean Six Sigma brings additional value to process improvement, as it integrates Six Sigma focus on elimination of defects and reduction of variation with Lean Manufacturing focus on waste and cycle time elimination [33]. According to Thomas, Barton, and Chuke-Okafor‘s [34] case study in a small engineering company which located in the United Kingdom, the integrated implementation of LSS on the production line where the pilot was implemented, there was a 55% reduction in scrap costs, an increase in overall equipment effectiveness (OEE) from 34 to 55%, a 34% increase in the time available for production and a 12% reduction in energy consumption per year.

LSS originated from manufacturing environment and it now effectively implemented in service concerns. It been used in shorten the customer fulfilment lead times for company. Su, Chiang, and Chang [35] carried out a case study on a help-desk service company in the area of information technology. As the main results, the authors found that with the implementation of LSS the company reduced the service time by nearly 52% .

Besides that, LSS can reduce the turnover and thus lower costs of production. This can be prove through the case study which been conducted by Laureani, Antony, and Douglas in a call centre [36]. They found that the service company able to reduce call time, decrease operator turnover and streamline the process with the implementation of LSS. Thus, the annual turnover of the service company fell from 35 to 25% and result a reduction of US$ 1.3 million per year in the costs for hiring process, training and dismissal, among others. Kumar et al. [33] also found that the implementation of LSS is resulted in a significant decrease in the number of defects occurred in the final product and an overall savings of around $140 000 per year in a die casting manufacturer [33].

In addition, Lean Six Sigma is also led to innovation. According to Byrne et al.'s [37] report, at first, Caterpillar Inc. facing stagnant revenue growth and thus the company decided to implement Lean Six Sigma to gain competitive advantage by breakthrough improvements in January 2001. Implementation of Lean Six Sigma led to product innovation which grows the revenue of the company by 80 percent in year 2005.

5. CONCLUSION

The research on Lean Six Sigma is still on initial stage. However, Lean Six Sigma is the likely to be the next popular methodology for continuous improvement [15]. There has been a great deal of academic research on the topic of Lean Six Sigma since 21th century. According to the database of Science Direct, it starts to have more and more journal article. The climate of the amount of Lean Six Sigma journal article is at year 2012 which reached 83 journal articles at that year. However, there are still some uncovered areas of LSS for obstacle and challenges during implementation of Lean Six Sigma.

As the literature shown previously, Lean Six Sigma has been equally beneficial both for manufacturing or service organizations. A review on the past and recent Lean Six Sigma literature has shown that previous researches include the results from different perspectives and are focus on health industry, Engineering industry, service industry, military and etc. The majority of the studies conducted mainly in overseas countries where there are clearer and more comprehensive processes of quality improvement practices. Fewer things have been investigated in Malaysia especially in automotive industries. Thus, there is a need to conduct a research on the impact of implementing Lean Six Sigma in automotive industries of Malaysia.

6. ACKNOWLEDGMENTS

This study was a tutorial practice for undergraduate student, the first author. Responsibility of presented information is with the student. Research consultation and method teaching was with the second author. This study is supported by University Malaysia Pahang research grant (RUD130375).

7. REFERENCES

[18] Womack, James P.; Daniel T. Jones, and Daniel Roos ,1990 . The Machine That Changed the World. Macmillan, New York, NY.
[19] Ricondo, I. and Viles, E. ,2005 ‗Six Sigma and its link to TQM, BPR, lean and the learning organization', *International Journal of Six Sigma and Competitive Advantage*, Vol. 1, No. 3 pp.323–354.
[20] Phillips, T. ,2000 . ―Building the lean machine‖. Advanced Manufacturing. January, pp. 21-6.
[21] Claycomb, C., Germain, R. and Droge, C. ,1999 . ―Total systems JIT outcomes: inventory, organization and financial effects‖. *International Journal of Physical Distribution & Logistics Management*, Vol. 29 No. 10, p. 612.
[22] Womack, James P.; Daniel T. Jones, and Daniel Roos ,2003 . Lean Thinking: Banish Waste and Create Wealth in Your Corporation. 2nd ed., Simon & Schuster, London.
[23] Gijo, E. V., and Scaria, J. ,2010 . ―Reducing rejection and rework by application of Six Sigma methodology in manufacturing process‖. *International Journal of Six Sigma and Competitive Advantage*, Vol. 6 No. 1/2, pp. 77-90.
[24] Coronado, R. B., and Antony, J. ,2002 . ―Critical success factors for the successful implementation of six sigma projects in organizations‖. *The TQM Magazine*, Vol. 14 No. 2, pp. 92-99.
[25] Aboelmaged, M.G. ,2010 . Six Sigma quality: a structured review and implications for future research. *International Journal of Quality & Reliability Management*, Vol 27 No 3, pp. 268 – 317.
[26] Heizer, J., & Render, B. ,2011 . Operation Management (Tenth ed.). England: Pearson Education.
[27] Mortimer, A.L.,2006 . Six sigma: effective handling of deep rooted quality problems. *Assembly Automation*. Vol 26 No 3, pp.200 – 204.
[28] Soti, A., Shankar, R. & Kaushal, O.P. ,2010 . 'Modeling the enablers of Six Sigma using interpreting structural modeling', *Journal of Modelling in Management*, Vol. 5 No 2, pp.124 - 141.
[29] Harry, M. J., & Lawson, J. R. ,1992 . *Six Sigma Producibility Analysis and Process Characterization. Reading*, MA: Addison-Wesley.
[30] Harry, M., Schroeder, R. ,2000 . Six sigma: the breakthrough strategy revolutionizing the world's top corporation. Doubleday, New York, NY.
[31] Kumar, S., and M. Sosnoski. ,2009 . ―Using DMAIC Six Sigma to Systematically Improve Shopfloor Production Quality and Costs.‖ *International Journal of Productivity and Performance Management* 58 (3): 254–273.
[32] Näslund, D. ,2008 . ―Lean, Six Sigma and Lean Sigma: Fads or Real Process Improvement Methods?‖. *Business Process Management Journal*. 14 (3): 269–287.
[33] Ronald D. Snee, ,2010 "Lean Six Sigma – getting better all the time", *International Journal of Lean Six Sigma*, Vol. 1 Iss: 1, pp.9 - 29
[34] Antony, J., J. L. Escamilla, and P. Caine.,,2003 . ―Lean Sigma.‖ *Manufacturing Engineer* 82 (4): 40–42.
[35] Kamensky, J. ,2008 . ―Is Lean Six Sigma cool‖. *PA Times*, Vol. 31 No. 4, p. 9.
[36] Arthur, Jay. ,2007 . *Lean Six Sigma Demistified*, McGraw Hill, New York.
[37] Marsh, J., Perer, T., Lanarolle, G., Ratnayake V. ,2011 . Lean Six Sigma: Exploring future potential and challenges. *Ventus Publishing ApS*.
[38] Arnheiter, E.D. and Maleyeff, J. ,2005 . ‗Research and concepts: the integration of lean management and Six Sigma'. *TQM Magazine*, Vol. 17, No. 1, pp.5–19.
[39] Bendell, T. ,2006 . ―A Review and Comparison of Six Sigma and the Lean Organizations.‖ *The TQM Magazine*, 18 (3): 255–262.
[40] Smith, B. ,2003 , ―Lean and Six Sigma – a one-two punch‖, Quality Progress, Vol. 36 No. 4, pp. 37-41.
[41] Antony, J., J. L. Escamilla, and P. Caine. ,2003 . ―Lean Sigma.‖ *Manufacturing Engineer* 82 (4): 40–42.
[42] Pepper, M. P. J., and T. A. Spedding. 2010. ―The Evolution of Lean Six Sigma.‖ *International Journal of Quality & Reliability Management* 27 (2): 138–155.

[43] Salah, S., A. Rahim, and J. A. Carretero. 2010. –The Integration of Six Sigma and Lean Management.‖ *International Journal of Lean Six Sigma* 1 (3): 249–274.
[44] Cusumano, M.A. ,1994 . –The limits of lean‖. *Sloan Management Review*, Vol. 35 No. 4, pp. 27-32.
[45] Bhuiyan, N. and Baghel A. 2005, –An overview of continuous improvement: from the past to the present‖, *Management Decision* Vol. 43 No. 5, 2005 pp. 761-771
[46] Nave, D. ,2002 . –How to compare six sigma, lean and the theory of constraints‖. *Quality Progress*. Vol. 35 No. 3, p. 73.
[47] Dove, R., 1999 . –Knowledge management, response ability and the agile enterprise‖. *Journal of Knowledge Management*, Vol. 3 No. 1, pp. 18-35.
[48] Andersson, R., Eriksson, H. and Torstensson, H. ,2006 , –Similarities and differences between TQM, six sigma and lean‖, *The TQM Magazine*, Vol. 18 No. 3, pp. 282-96.
[49] Magnusson, K., Kroslid, D. and Bergman, B. ,2003 . Six Sigma – *The Pragmatic Approach*. Lund, Student literature.
[50] Kumar, M., Antony, J., Singh, K.R., Tiwari, K.M. and Perry, D. (2006 . –Implementing the Lean Sigma framework in an Indian SME: a case study‖. Production Planning & Control, Vol. 17 No. 4, pp. 407-23.Bowman, M., Debray, S. K., and Peterson, L. L. 1993. Reasoning about naming systems.
[51] Thomas, A., R. Barton, and C. Chuke-Okafor. ,2009 . –Applying Lean Six Sigma in a Small Engineering Company – A Model for Change.‖ *Journal of Manufacturing Technology Management*. 20 (1): 113–129.
[52] Su, C.-T., T.-L. Chiang, and C.-M. Chang. 2006. –Improving Service Quality by Capitalising on an Integrated Lean Six Sigma Methodology.‖ *International Journal of Six Sigma and Competitive Advantage* 2 (1): 1–22.
[53] Laureani, A., J. Antony, and A. Douglas. ,2010 . –A. Lean Six Sigma in a Call Centre: A Case Study.‖. *International Journal of Productivity and Performance Management* 59 (8): 757–768.
[54] Byrne, G., Lubowe, D. and Blitz, A. ,2007 . –Using a Lean Six Sigma approach to drive innovation‖. *Strategy & Leadership*, Vol. 35, No. 2, pp. 5-10.

****