



A Review Paper on Recent developments in Six-Sigma

Abhijit B. Dahagaonkar¹, Adinath S. Aher², Manoj P. Bauskar³

Students, Department of Mechanical Engineering^{1,2}

Assistant Professor, Department of Mechanical Engineering³

All India Shri Shivaji Memorial Society's College of Engineering, Pune, Maharashtra, India

Abstract: *This research review investigates at current developments in the management strategies of Six-Sigma and lean production for manufacturing systems. This study includes a thorough description of Six-Sigma and lean production processes, including how they are utilized in manufacturing, where they are employed, their advantages, and the progress that has been accomplished thus far. In order to provide the notion a deeper and more thorough knowledge, the various forms of lean six-sigma were also described with brief examples.*

Keywords: Six-Sigma, Lean, Development, Manufacturing

REFERENCES

- [1]. Aghili, S. (2009), "A Six-Sigma Approach to Internal Audits", Strategic Finance, vol. 90, no. 8, pp. 38-43
- [2]. Al-Mishari, S.T. and Suliman, S. (2008), "Integrating Six-Sigma with other reliability improvement methods in equipment reliability and maintenance applications", Journal of Quality in Maintenance Engineering, vol. 14, no. 1, pp. 59-70
- [3]. Anand, R. B., Shukla, S. K., Ghorpade, A., Tiwari, M. K. and Shankar, R. (2007), "Six-Sigma-based approach to optimise deep drawing operation variables", International Journal of Production Research, vol.45, no. 10, pp. 2365-2385
- [4]. Andersson, R. and Eriksson, H. and Torstensson, H. (2006), "Similarities and differences between TQM, Six-Sigma and lean", TQM Magazine, vol. 18, no. 3, pp. 282-296
- [5]. Antony, J. (2004), "Some pros and cons of Six-Sigma: an academic perspective", TQM Magazine, vol. 16, no. 4, pp. 303-306
- [6]. 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. 633-646
- [7]. Arnheiter, E.D. and Maleyeff, J. (2005), "The integration of lean management and Six-Sigma", The TQM Magazine, vol. 17, no. 1, pp. 5-18
- [8]. Baines, T.S., Lightfoot, H.W., Benedettini, O. and Kay, J.M. (2009), "The servitization of manufacturing: a review of literature and reflection on future challenges", Journal of Manufacturing Technology Management, vol. 20, no. 5, pp. 547-567
- [9]. Banuelas, R. and Antony, J. (2004), "Six-Sigma or Design for Six-Sigma", TQM Magazine, vol. 16, no. 4, pp.250-263
- [10]. Black, K. and Revere, L. (2006), "Six-Sigma arises from the ashes of TQM with a twist", International Journal of Health Care Quality Assurance, vol. 19, no. 3, pp. 259-266
- [11]. Brady, J.E. and Allen, T.T. (2006), "Six-Sigma Literature: A Review and Agenda for Future Research", Quality and Reliability Engineering International, vol. 22, pp. 335-367
- [12]. Breyfogle III, F. W. (2008), "Better Fostering Innovation: 9 steps that improve lean Six-Sigma", Business Performance Management Magazine, vol. 6, no. 3, pp. 16-20



- [13]. Bunce, M. M., Wang, L. and Bidanda, B. (2008), "Leveraging Six-Sigma with industrial engineering tools ins crateless retort production", *International Journal of Production Research*, vol. 46, no. 23, pp. 6701-6719
- [14]. Chakrabarty, A. and Tan, K. C. (2007), "The current state of Six-Sigma application in services", *Managing Service Quality*, vol. 17, no. 2, pp.194-208
- [15]. Chung, Y.C., Hsu, Y.W., and Tsai, C.H. (2008), "An empirical study on the correlation between Critical DFSS success factors, DFSS implementation activity levels and business competitive advantages in Taiwan's high-tech manufacturers.", *Total Quality Management*, vol. 19, no. 6, pp. 595-607
- [16]. Coleman, S. (2008), "Six-Sigma: An opportunity for statistics and for statisticians", *Significance*, vol. 5, issue 2, pp. 94-96
- [17]. Dasgupta, T. (2003), "Using the six-sigma metric to measure and improve the performance of a supply chain", *Total Quality Management and Business Excellence*, vol. 14, no. 3, pp. 355-366
- [18]. Davison, L. and Shaghana, K.A (2007), "The Link between Six-Sigma and Quality Culture: An Empirical Study", *Total Quality Management*, vol. 18, no. 3, pp. 249- 265
- [19]. de Koning, H. and de Mast, J. (2006), "A rational reconstruction of Six-Sigma's breakthrough cookbook", *International Journal of Quality & Reliability Management*, vol. 23, no. 7, pp.766-787
- [20]. de Koning, H., de Mast, J., Does, R.J.M.M., Vermaat, T. and Simons, S. (2008), "Generic Lean Six-Sigma Project Definitions in Financial Services", *Quality Management Journal*, vol. 15, no. 4, pp. 32-45
- [21]. Edgeman, R. L. and Dugan, J. P. (2008), "Six-Sigma from products to pollution to people", *Total Quality Management*, vol. 19, no. 1-2, pp. 1-9
- [22]. Ehie, I. and Sheu, C. (2005), "Integrating Six-Sigma and theory of constraints for continuous improvement: A case study", *Journal of Manufacturing Technology Management*, vol. 16, no. 5, pp. 542-553
- [23]. Ferrin, D., Miller, M. and Muthler, D. (2005), "Lean sigma and simulation, so what's the correlation? V2", in: *Proceedings of the 2005 Winter Simulation Conference*, 4-7 December 2005, Orlando, Florida, pp. 2011-2015
- [24]. Furterer, S. and Elshennawy, A.K. (2005) "Implementation of TQM and lean Six-Sigma tools in local government: a framework and a case study", *Total Quality Management & Business Excellence*, vol. 16, issue 10, pp. 1179 - 1191
- [25]. Gladwin, B. (2003), "Six-Sigma& Simulation", *Promodel White Paper*, last accessed 2 June 2010
- [26]. Goh, T. N. and Xie, M. (2004), "Improving on the Six-Sigma paradigm", *TQM magazine*, vol. 16, no. 4, pp. 235-240
- [27]. Gowen III, C. R., Stock, G. N. And McFadden, K. L. (2008), "Simultaneous implementation of Six-Sigma and knowledge management in hospitals", *International Journal of Production Research*, vol. 46, no. 23, pp. 6781-6795
- [28]. Green, F. B. (2006), "Six-sigma and the revival of TQM", *Total Quality Management and Business Excellence*, vol. 17, no. 10, pp. 1281-1286
- [29]. Hagemeyer, C., Gershenson, J. K. and Johnson, D. M. (2006), "Classification and application of problem solving quality tools", *TQM Magazine*, vol. 18, no. 5, pp. 455-483
- [30]. Haikonen, A., Savolainen, T. and Järvinen, P. (2004), "Exploring Six-Sigma and CI capability development: Preliminary case study findings on management role", *Journal of Manufacturing Technology Management*, vol. 15, no. 4, pp. 369-378
- [31]. Hammer, M. (2002), "Process management and the future of Six-Sigma", *MIT Sloan Management Review*, vol. 43, no. 2, pp. 26-32
- [32]. Han, H.S., Chae, M.J., Im, K.S. and Ryu, H.D. (2008), "Six-Sigma-Based Approach to Improve Performance in Construction Operations", *Journal of Management in Engineering*, vol. 24, no. 1, pp. 21-31
- [33]. Hensley, R. L. and Dobie, K. (2005), "Assessing readiness for Six-Sigma in a service setting", *Managing Service Quality*, vol. 15, no. 1, pp. 82-101
- [34]. Hong, K., Nagarajah, R., Iovenitti, P., and Dunn, M. (2007), "A Sociotechnical Approach to Achieve Zero



- Defect Manufacturing of Complex Manual Assemblies”, *Human Factors and Ergonomics in Manufacturing*, vol. 17, no. 2, pp. 137–148
- [35]. Hsieh, C.T., Lin, B. and Manduca, B. (2007), “Information Technology and Six-Sigma Implementation”, *Journal of Computer Information Systems*, vol. 47, no. 4, pp. 1-10
- [36]. Johnston, A. B., Maguire, L. P., McGinnity, T. M. (2008), “Disentangling causal relationships of a manufacturing process using genetic algorithms and six-sigma techniques”, *International Journal of Production Research*, vol.46, no. 22, pp.6251-6268
- [37]. Kumar, M., Antony, J., Antony, F. J. and Madu, C. N. (2006), “Winning Customer Loyalty in an Automotive Company through Six-Sigma: a Case Study”, *Quality Reliability Engineering International*, vol. 23, pp. 849–866
- [38]. Kumar, M., Antony, J., Madu, C. N., Montgomery, D. C., and Park, S. H. (2008), “Common myths of Six-Sigma demystified”, *International Journal of Quality and Reliability Management*, vol. 25, no. 8, pp. 878-895
- [39]. Kumar, S., Jensen, H. and Menge, H. (2008), “Analyzing Mitigation of Container Security Risk Using Six-Sigma DMAIC Approach in Supply Chain Design”, *Transportation Journal*, vol. 47, no. 2, pp. 54-67
- [40]. Kumar, U. D., Nowicki, D., Ramirez-Marquez, J. R. and Verma, D. (2007), “On the optimal selection of process alternatives in a Six-Sigma implementation”, *International Journal of Production Economics*, no. 111, pp. 456-467
- [41]. Kumar, S. and Bauer, K.F. (2010) “Exploring the Use of Lean Thinking and Six-Sigma in Public Housing Authorities”, *Quality Management Journal*, vol. 17, no. 1
- [42]. Kwak, Y.H. and Anbari, F.T. (2006), “Benefits, Obstacles and future of Six-Sigma approach”, *Technovation*, vol. 26, no. 5-6, pp. 708-715
- [43]. Lee-Mortimer, A. (2006), “Six-Sigma: a vita improvement approach when applied to the right problems, in the right environment”, *Assembly Automation*, vol. 26, no. 1, pp. 10-17
- [44]. Lee-Mortimer, A. (2007), “Leading UK manufacturer probes the potential of Six-Sigma”, *Assembly Automation*, vol. 27, no. 4, pp. 302-308
- [45]. Lin, L. C., Li, T. S. and Kiang, J. P. (2008), “A Continual Improvement Framework with Integration of CMMI and Six-Sigma Model for Auto Industry”, *Quality and Reliability Engineering International*, vol. 25, issue 5, pp. 551 - 569
- [46]. Maciel Junior, H., Batista Turrioni, J., Cesar Rosati, A., Garcia Neto, D., Kenji Goto, F., Fujioka Mogni, J., Machado Fernandes, M. (2008), “Application of Design for Six-Sigma (DFSS) on an Automotive Technology Development Process”, *SAE Technical paper series*
- [47]. Mader, D. P (2006), “Deploying the 'D' in DFSS”, *Quality Progress*, vol. 39, no. 7, pp.73-74
- [48]. Mahanti, R. and Antony, J. (2005), “Confluence of Six-Sigma, Simulation and Software development”, *Managerial Auditing Journal*, vol. 20, no.7, pp.739-762
- [49]. Mcadam, R. and Evans, A. (2004), “Challenges to Six-Sigma in a high technology mass manufacturing environments”, *Total Quality Management*, vol. 15, no. 5-6, pp. 699-706
- [50]. McAdam, R. and Laffert, B. (2004), “A multilevel case study critique of Six-Sigma: Statistical control or strategic change?”, *International Journal of Operations and Production Management*, vol. 24, no. 5-6, pp. 530-549
- [51]. McCarthy, B. and Stauffer, R. (2001), “Enhancing Six-Sigma through simulation with iGrafx process for Six-Sigma”, in: *Proceedings of the 2001 Winter Simulation Conference*, vol. 2, 9-12 December 2001, Arlington, USA, p. 1241-1247
- [52]. Miron, J.R. and Skarke, P. (1981), “Non-price information and price sustainability in the Koopmanns-Beckmann problem”, *Journal of Regional Science*, vol.21, no.1, pp.117-122
- [53]. Mitra, A. (2004), “Six-Sigma Education: a critical role for academia”, *TQM magazine*, vol. 16, no. 4, pp.293-302



- [54]. Montes, F.J.L. and Molina, L.M. (2006), "Six-Sigma and Management Theory: Processes, Content and Effectiveness", *Total Quality Management*, vol. 17, no. 4, pp. 485-506
- [55]. Morgan, J. and Brenning, M. J. (2006), "Six-Sigma and the Future of Quality", *Management Services*, vol. 50, no. 2, pp. 46-47
- [56]. Murugappan, M. and Keeny, G., (2003), "Blending CMM and Six-Sigma to meet business goals", *IEEE Software*, vol. 20, no.2, pp.42-48
- [57]. Näslund, D. (2008), "Lean, Six-Sigma and lean sigma: Fads or real process improvement methods?", *Business Process Management Journal*, vol. 14, no. 3, pp. 269-287
- [58]. Nonthaleerak, P. and Hendry, L. (2008), "Exploring the Six-Sigma phenomenon using multiple case study evidence", *International Journal of Operations and Production management*, vol. 28, no. 3, pp.279-303
- [59]. Oke, S. A. (2007), "Six-Sigma: A literature Review", *South African Journal of Industrial Engineering*, vol. 18, no. 2, pp. 109-129
- [60]. Pantano, V., Kane, P. O. and Smith, K. (2006), "Cluster-Based Six-Sigma Deployment in Small and Medium Sized Enterprises", *Management of Innovation and Technology*, vol. 2, pp. 788-792
- [61]. Patel, S.C. and Zu, X. (2009), "E-government application development using the Six-Sigma approach", *Electronic Government, an International Journal*, vol. 6, no. 3, pp. 295 - 306
- [62]. Proudlove, N. and Moxham, C. and Boaden, R. (2008), "Lessons for lean in healthcare from using Six-Sigma in the NHS", *Public Money and Management*, vol. 28, no. 1, pp. 27-34
- [63]. Raja, A. (2006), "Simple Tools for Complex Systems", *Quality Progress*, vol. 39, no. 6, pp. 40-44
- [64]. Ranch, H. (2006), "Xerox Find the Right Tool for Tracking Continuous Improvement", *Manufacturing Business Technology*, vol. 24, no. 2, pp. 42-45
- [65]. Savolainen, T. and Haikonen, A. (2007), "Dynamics of organizational learning and continuous improvement in Six-Sigma implementation", *TQM Magazine*, vol. 19, no. 1, pp. 6-17
- [66]. Schroeder, R. G., Linderman, K., Liedtke, C. and Choo, A. S. (2008), "Six-Sigma: Definition and Underlying theory", *Journal of operations management*, no. 26, pp. 536-554
- [67]. Sehswail, L. and DeYong, C. (2003), "Six-Sigma in health care", *Leadership in Health Services*, vol. 16, no. 4, pp. 1-5
- [68]. Senapati, N. R. (2004), "Quality and Reliability Corner: Six-Sigma: myths and realities", *International Journal of Quality and Reliability Management*, vol. 21, no. 6/7, pp.683-690
- [69]. Shah, R. and Chandrasekaran, A. and Linderman, K. (2008), "In pursuit of implementation patterns: The context of Lean and Six-Sigma", *International Journal of Production Research*, vol. 46, no. 23, pp. 6679-6699
- [70]. Teresko, J. (2008), "How to organize for lean/Six-Sigma", *Industry Week*, vol. 257, no.11, pp. 38-41
- [71]. Thawani, S. (2004), "Six-Sigma – strategy for organizational excellence", *Total Quality Management*, vol. 15, no. 5-6, pp.655-664
- [72]. Thawesaengskulthai, N. and Tannock, J.D.T. (2008), "A Decision Aid for Selecting Improvement Methodologies", *International Journal of Production Research*, vol. 46, no. 23, pp. 6721-6737
- [73]. Thomas, A. and Barton, R. and Chuke-Okafor, C. (2009), "Applying lean Six-Sigma in a small engineering company- A model for change", *Journal of Manufacturing Technology Management*, vol. 20, no. 1, pp. 113-129
- [74]. van den Heuvel, J., Does, R.J.M.M. and Verver, J.P.S. (2005), "Six-Sigma in healthcare: lessons learned from a hospital", *International Journal of Six-Sigma and Competitive Advantage*, vol. 1, no. 4, pp. 380 - 388
- [75]. van Iwaarden, J., van Der Wiele, T., Dale, B., Williams, R. and Bertsch, B. (2008), "The Six-Sigma improvement approach: a transnational comparison", *International Journal of Production Research*, vol. 46, no. 23, pp. 6739-6758
- [76]. Ward, S.W, Poling, S.R. and Clipp, P. (2008), "Selecting Successful Six-Sigma Projects", *Quality*, vol. 47, no. 10, pp. 50-51



- [77]. Watson, G.H. (2005), "Design for Six-Sigma: Innovation for Enhanced Competitiveness", Goal/QPC
- [78]. Watson, G.H. and DeYong, C.F. (2010), "Design for Six-Sigma: caveat emptor", International Journal of Lean Six-Sigma, vol. 1, No. 1, pp. 66-84
- [79]. Wei, C., Sheen, G., Tai, C. and Lee, K. (2010), "Using Six-Sigma to improve replenishment process in a direct selling company, Supply Chain Management, vol. 15, issue 1, pp. 3-9
- [80]. Welch, J. (2005), "Six-Sigma Leaders", Quality, vol. 44, no. 3, pp. 80-80 William, S. (2009), "The Lean Toolkit, Part I", CiruiTree, vol. 22, no. 2, pp. 36
- [81]. Yang, H.M., Choi, B.S., Park, H.J., Suh, M.S. and Chae, B. (2007), "Supply chain management Six-Sigma: a management innovation methodology at the Samsung Group", Supply Chain Management: An International Journal, vol. 12, no. 2, pp. 88-95