

Quality management approach in construction equipment manufacturing

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Abstract

Over the recent decades, quality management practises have been documented extensively, with concepts often being termed the latest management fad. This study tackles a debate that has been a topic of discussion within academic literature for several decades; is Total Quality Management a management fad, which should be replaced by a new quality philosophy. This paper presents the TQM versus Six Sigma debate, by critically reviewing existing literature on the two approaches, as well as providing results from research within a leading construction equipment manufacturer. The results highlight that Six Sigma should be implemented using TQM as a foundation; thus presenting the overall finding that TQM and Six Sigma are compliments, not substitutes.

Key Words: TQM, Six Sigma, construction equipment manufacturer

TQM vs. Six Sigma

Freidman (2002) states that economists consider manufacturing industries to be the wealth-producing sector of the economy, and see service industries as wealth-consuming sectors. This highlights the importance of manufacturing industries despite the fact that they are only the second largest sector within the European Union; comprising 25% of the Gross Domestic Product (GDP), which significantly trails behind the service sector which is 73.2% (CIA, 2010). According to BIS (2011), manufacturing has been, and continues to be, a central part of the UK economy; accounting for 12.8% of UK GDP and in 2009 accounted for 11%, or £140 billion, of national economic output (Maer 2011). 3.38% of the UK manufacturing national economic output is comprised from the heavy duty machinery production, which in 2009 was worth just over £4.7 billion (JCB 2009). This sector will be studied in this paper as the target industry.

Due to the ever-increasing competitiveness of the manufacturing industry, quality plays a vital role for organisations in their attempt to gain a world-wide market edge by meeting customers' needs more effectively, and thus increasing efficiency and reducing costs (Tennant 2001). It has been recognised that the 'quality of management' is equally as important as the 'management of quality'. At one time, there were only few choices of Quality Management approaches; now, however, a plethora of quality improvement initiatives have been created and accumulated over the past fifty years.

TQM: A Management Fad?

Over the recent decades, quality management practises have been documented extensively, with concepts often being misunderstood, resulting in being termed the latest "management fad" (Dahlgaard and Dahlgaard-Park 2006, p. 263). One of the most deliberated management fads of recent decades has been Total Quality Management. Since the mid-1990's, articles have appeared that have "touted the demise and death of Total Quality Management", questioning the value and worth of the management approach (Green 2006, pp. 1281-1282). Reflecting upon the struggles of organisations attempting to apply the TQM approach, Albrecht (1992, p. 271) predicted that the fate of TQM would mirror the "dinosaur-like extinction" of the old management by objectives (MBO), which during the peak of its success, was supposed to transform the world of business. The discussion about the "fall" of TQM (Douglas, 2006), and the need to "give TQM a decent burial" (Albrecht 1992, p. 272), has not been restricted to academics, as businesses and the media have increasingly joined the wave of criticism (Yong and Wilkinson 1999, p. 138) most notably Byrne (1997), who stated that TQM is "as dead as a pet rock".

Naslund (2008), claimed that one way to measure whether TQM is a management fad, was to observe the number of academic publications, as identified through the ABI/Inform data base, over a thirty year period from 1975 to 2004. In the late 1980's and early 1990's, TQM experienced enormous popularity (Naslund 2008). Despite this early popularity, reports presenting a lack of results, problems with implementation, and TQM failure, started to appear in the late 1980's, thus leading to a significant drop in the number of published TQM articles (Naslund 2008, p. 276).

Furthermore, Black and Revere (2006) highlighted one shortfall of TQM being its inability to remove identified root causes, thus leading to improvement gains being lost over time and organisations reverting back to their original performance. In addition, Park-Dahlgaard (2002) identified two main forms in which TQM has been negatively criticised: the way in which some organisations have failed to implement the approach correctly, and that there is a lack of consensus about the true definition of TQM. Lau and Anderson (1998) stated that in the July 1995 'Quality Progress' magazine contained thirteen articles on TQM, in which twelve different definitions of TQM were given. TQM has been defined, amongst other things, as "...a philosophy..." (Oakland 1993), "...a culture..." (Dahlgaard, et al. 1998), "...an approach..." (Dale 1999) and "an Strategy" (Bohan 1998, pp. 13-14). Because of this lack of clarity, it has failed to be fully implemented correctly, as TQM supporters will have had little guidance of what to actually target and apply (Bergquist et al. 2005).

Research has shown that various academics have undertaken surveys with the results concluding that TQM has failed to bring about financial gains within organisations. The

finding most cited in Quality Management commentaries - the damaging survey carried out by Kearney (1992) - concluded that around 80% of TQM initiatives have failed. Kolesar (1995) stated that the reason for the failure of this particular approach was the gap between what practitioners advocated and what was actually being implemented. Green (2006, p. 1282) supports this argument by saying that TQM is an “elusive goal” that leads to unrealistic organisational expectations and the desire for immediate results. Professor S.K Neogy (in Antony 2007), believes that the reason for the failure of TQM is not because of its philosophy, but due to the lack of a correct implementation framework. Therefore, in order to adopt TQM, organisations were required to hold a deeper understanding of what it was about, which generally led to many organisations turning their back on TQM (Douglas 2006).

Although TQM is a concept that is hard to grasp and difficult to implement, research by Bergquist et al. (2005) has concluded that TQM still generates benefits if used properly, and is apparently thriving in organisations as evident by the number of national and international quality award winners (Van Der Wiele et al. 2002). Whilst there are many reports and remarks stating the death of TQM, there are also studies that underpin the merits of employing TQM as a powerful quality roadmap, and highlight the many benefits and values of such a management approach (Yong and Wilkinson 1999). Bergquist et al. (2005) argue that critics will always find organisations that are dissatisfied with what has been implemented, and can therefore produce damaging academic articles.

Various researchers, such as Andersson et al. (2006) have responded to criticisms against TQM, presenting that, in reality, organisations that have successfully implemented TQM outperform other organisations financially. This is also supported by Lemak and Reed (1997) who studied 60 companies that had practiced TQM for a period of at least five years, and due to this long-term commitment they managed to see an improved profit margin. Similarly, a survey of 350 HR managers performed by the Institute of Personnel Management (1993), found that 76% of organisations had experience with Quality Management; 65% of which rated Total Quality Management as “successful”, with a mere 5% reporting their initiatives as “unsuccessful” (Yong and Wilkinson 1999 p. 138). In addition, AT&T Transmission Systems Business Unit has been highlighted as an example of where TQM has brought about significant improvements and is considered a success (Evans and Lindsay 2002, p. 50). Within six years of implementation, the unit achieved a 10-fold improvement in equipment product quality, and \$400million in cost improvements, all of which occurred in the same period that five major competitors experienced financial losses. These examples of success support that TQM is no “quick fix” and only brings about success and financial gains in the long term (Dahlgaard and Dahlgaard-Park 2006, p. 272).

The main concern is that many organisations have advocated partial and ad-hoc TQM efforts, which are far from the full TQM, thus providing an unfair indication of what TQM can achieve (Yong and Wilkinson 1999). Although research suggests that TQM has been tried and found inadequate, Evans (1995, p. 5) argues that it has in fact “either been tried and found difficult, or tried, yet misunderstood”. Therefore, although it may be said that TQM is alive and well (Douglas 2006), the success of TQM does depend on several factors, such as: the type of organisation that applies TQM concepts and what they define by TQM (Bergquist et al. 2005). In other words, TQM is not an exact formula and that one size does not fit all.

Nevertheless, TQM is flexible in its ability to fit particular organisations (Ehigie and McAndrew 2005). After all:

“TQM is a philosophy, not a science. Philosophies are seldom suddenly born, and they almost never die; they simply get improved upon” Paton (1994 p.3).

Six-Sigma: An alternative

Klefsjö, et al. (2006) proclaim that other Quality Management concepts, such as Six Sigma, have grown in popularity. Over the recent years, Six Sigma has been one of the few technically oriented initiatives to generate interest from business leaders, the financial community, and the popular media (Hoerl 2001). Many organisations have moved their strategies and practices towards such approaches (Andersson et al. 2006). The significance of Six Sigma's success can be traced to Motorola, where between 1987 and 1997, the organisation achieved a “fivefold growth in sales with profits climbing nearly 20 per cent per year”, (Klefsjö, et al. 2001, p. 32). Andersson et al. (2006) present an example of Six Sigma's positive financial impact through Volvo Cars in Sweden, who claim that between 2000 and 2002, Six Sigma contributed over €55 million to the bottom line.

Six Sigma overcomes the deficiencies that were evident within TQM, such as unclear quality goals and the failure to break down internal barriers (Pande et al. 2000). The approach represents a new collective and multidimensional approach to quality (Harry 2000), which has showed a much better record of effectiveness than TQM (Antony 2004 and Cheng 2008). Thus suggesting Six Sigma is a “replacement for Total Quality Management” (Green 2006, p. 1283).

In the current very high global competition and cost reductions climate, Six Sigma achieves significantly more on areas “where some existing TQM efforts have lost focus” (McAdam et al. 2005, p. 168). Andersson et al. (2006, p. 291) believe this is because “six sigma programmes talk the top managers' language”, which is “the financial gains of the improvement”.

Six Sigma's rise in popularity is also evident through the increased frequency of academic publications, as shown by Aboelmaged (2010), who reviewed the distribution of 417 Six Sigma articles over the period from 1992-2008. Despite the apparent limited academic publications before 2000, literature on Six Sigma flourished between 2000 and 2006, with the frequency of journal articles significantly increasing over this period. Although the “blooming years for Six Sigma” were followed by a slight decline in 2007, the escalation in growth of Six Sigma articles in 2008 onward was significant (Aboelmaged 2010, p. 271).

In addition, Black and Revere (2006) argue that Six Sigma has risen from the ashes of TQM and its inadequacies by introducing new concepts and approaches. They also believe that Six Sigma applies root-cause techniques in order to discover variability, ensuring a more thorough search than other quality improvement efforts that have gone before. This is because Six Sigma is data-driven and therefore uses measurements to analyse problems and thereby improve the process or outcome. While TQM has no way to measure the level of quality, the Six Sigma metrics enables organisations to position their quality improvement effort in comparison to others (Black and Revere 2006). It is, therefore, argued that Six

Sigma projects are closely tied to business goals and objectives that are usually based around satisfying customer needs (Ingle and Roe 2001).

Despite a lack of criticism against Six Sigma, some academics state that it is merely an add-on project management tool (Nonthaleerak and Hendry 2008), and a repacked version of TQM which has simply added and retracted a few components and sold under a different name (Bergquist et al. 2005). Some researchers believe Six Sigma has been around for many years in the form of problem solving, team building, and SPC, and that there is nothing new about it (Reed 2000). The newness should, however, be appreciated in the form of its improved operational methods, tools and techniques, such as developments in statistical and operational methods of data analysis (Goh and Xie 2003 and McAdam et al. 2005).

It has also been described as “old wine in a new bottle”, for the reason that most of the tools involved within it have been around for several decades (Thawani 2004). Furthermore, Andersson et al. (2006) argue that the Six Sigma programme should not be considered as a replacement for TQM, for the reason that it is not as successful in improving customer satisfaction as the programme focusses primarily on financial savings. Literature by Klefsjö, et al. (2001, p. 34) rather supports that Six Sigma should be positioned in the larger context; Six Sigma is simply a methodology within the framework of TQM. As shown in Figure 1, TQM should be considered as a continuously evolving management system that is comprised of values, methodologies and tools.

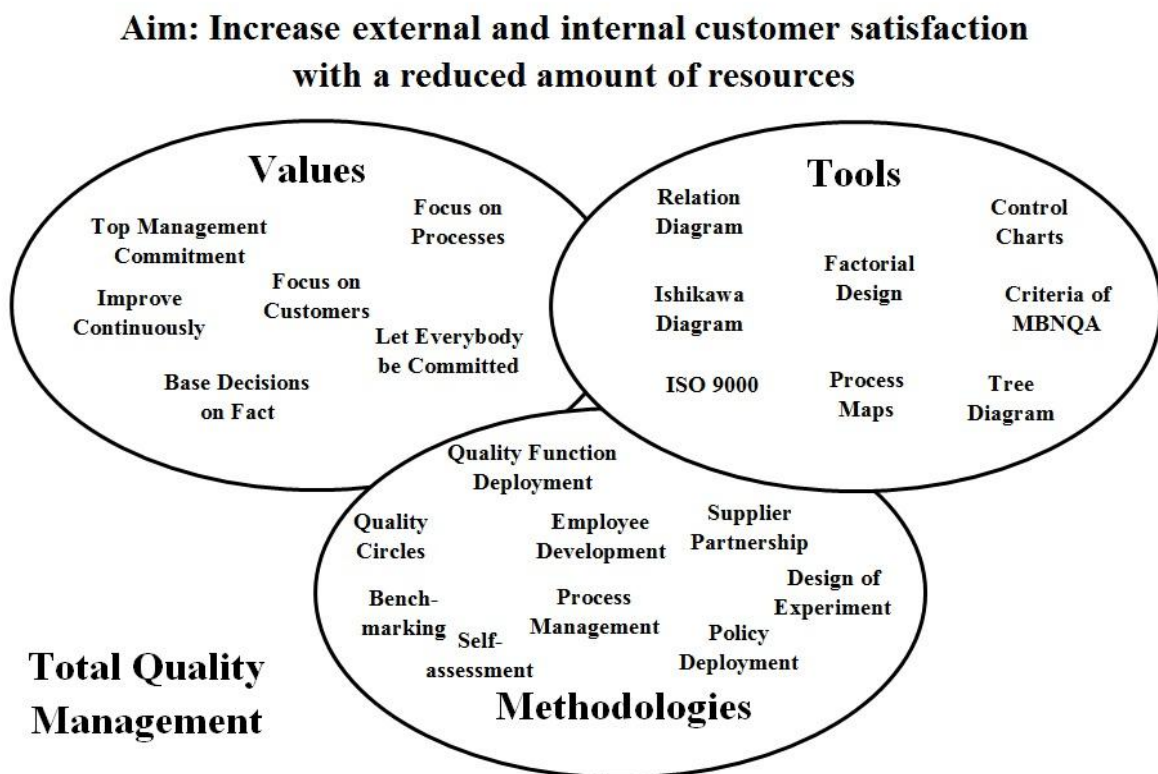


Figure 1 – Total Quality Management (Hellsten and Klefsjö 2000, p. 241)

Six Sigma: A compliment?

When debating the issue of which ‘roadmap’ is the best to follow when an organisation wants to achieve a world-class quality, Dahlgaard and Dahlgaard-Park (2006) state that alternative roadmaps to TQM are very dangerous to embark on without the right company culture. Companies should understand that such simple roadmaps like Six Sigma, will never work without a cultural background of the core principles of TQM. Six Sigma should only be regarded as a new ‘roadmap’ to follow, once TQM has already been implemented, or once the organisation is in the process of implementing it (Dahlgaard and Dahlgaard-Park 2006). However, Revere and Black (2003) argue that TQM might act as a roadblock for implementing Six Sigma due to the time and capital invested into establishing and promoting such a programme only to start a fresh with an alternative programme. Fortunately organisations can integrate existing TQM efforts with many Six Sigma models and concepts, thus allowing a seamless adoption of Six Sigma, which is key to a successful implementation of a quality management system (Cheng 2008).

On the other hand, it is suggested that Six Sigma is important to the success of TQM as it supports all six of the values within TQM, and illustrates a dynamic management system (Klefsjö, et al. 2001). Lucas (2002) also supports this by saying that Six Sigma strengthens TQM efforts through a strategic approach. Both concepts share the same aim: customer satisfaction and financial results will improve through waste and resource reduction (Andersson et al. 2006).

It has also been demonstrated that the integration of TQM with Six Sigma metrics, provides a measure of comparability used to aid quality improvement (Revere and Black 2003). A survey by Cheng (2009) highlighted that 11 companies were shown to be effective in implementing Six Sigma through analysis of SPSS. This survey showed it is possible for companies to implement Six Sigma under the framework of TQM activities. It was also highlighted by McAdam et al. (2005) that most of the organisations that claim success from Six Sigma, such as Motorola and GE, also have well established TQM programmes. Cheng (2008) presents Kinpo Electronics (KE) as an organisation that has achieved continuous improvement and competitive advantage, via the integration of TQM activities and the Six Sigma approach. Cheng (2008, pp. 193-194) also states that KE’s addition of Six Sigma to its business system, gave the organisation almost all of the elements of TQM; “the current business system + Six Sigma = TQM”. Therefore, based on this formula, Cheng (2008) believes that TQM remains dominant in modern industry as an overall quality programme.

In terms of the system, Cheng (2008) summarises that TQM’s improvement activities, such as QCC, QIT, QA and the ISO system, all represent TQM’s basic mechanisms that must be secured and cannot be abandoned when implementing Six Sigma. Klefsjö, et al. (2006, p. 175) conclude “Feel free to use Six Sigma, but do try to integrate it with TQM, or else you may end up with too thin a soup that may separate and come apart”

To summarise, implementing Six Sigma via TQM activities require two shifts; moving from PDCA to DMAIC and from inter-organisation activities to cross functional teams, and moving from TQM’s quality index to reduce the system’s defect rate and to align with Six Sigma’s financial focus (Cheng 2008).

Results

Within heavy duty machinery production, there are five leading manufacturers in Europe, as shown in Figure 2, the top five being JCB, Caterpillar, Volvo, Kubota and Hitachi.

J C Bamford Excavators Ltd is one of the world's biggest manufacturers of construction equipment, boasting some of the finest engineering facilities across the globe whilst maintaining a reputation for unrivalled customer service (JCB 2009). Having both TQM and Six Sigma experience in machine assembly and in their engine site, respectively, JCB was chosen to be studied in this research. JCB is located on four different continents, with sites in the UK, Brazil, China, Germany, India and North America. JCB's product range of over 300 machine types is distributed to their global customer base, stretching over 150 countries, via 1,500 dealer depot locations; employing over 8,000 people (JCB 2009).

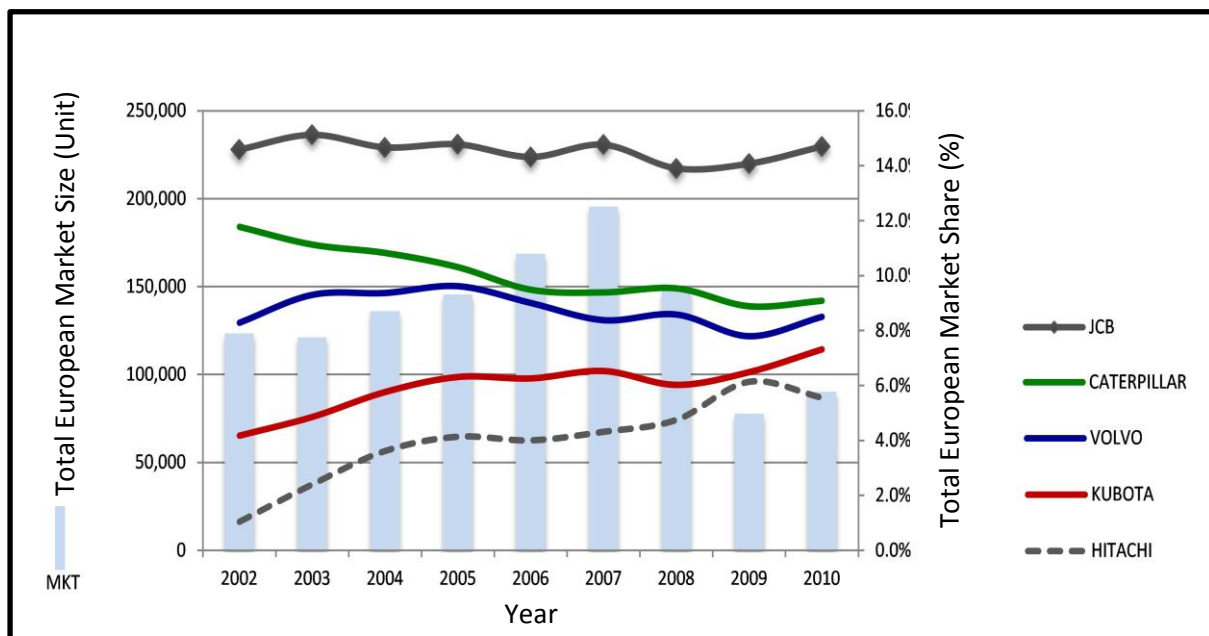


Figure 2 - A graph to show the market size of the Heavy Duty Machinery Industry and the market share of the top five competitors within

This research focusses upon results from two assembly lines; JCB Compact Products' small machine production, and JCB Power Systems' engine production. JCB's Compact Products plant has traditionally put TQM in practice, while the engine production site, exploiting experts from automotive sector, has managed to put Six Sigma in action on the basis of the company's expertise and the existing foundations of the TQM approach.

Figure 3 draws a direct comparison between the percentage of fault free products at both Six Sigma and TQM production lines, reported from equivalent quality control stages at both production sites; however, the results do not present the end product quality. The products names and the stage of quality control are kept anonymous in this paper for the sake of confidentiality. It is clearly evident that both approaches have brought high levels of quality to the company. The Six Sigma-TQM approach has, however, achieved a higher consistency of results; with results varying only 0.87%, as opposed to the variance of 5.3% shown by the TQM practice. This therefore indicates that Six Sigma-TQM achieves faster, better and more consistent results than TQM.

However, as mentioned earlier, it must be noted that Six Sigma in JBC's engine site has been built up on the company's TQM principles, thus supporting the argument that TQM is a valuable foundation for implementing Six Sigma.

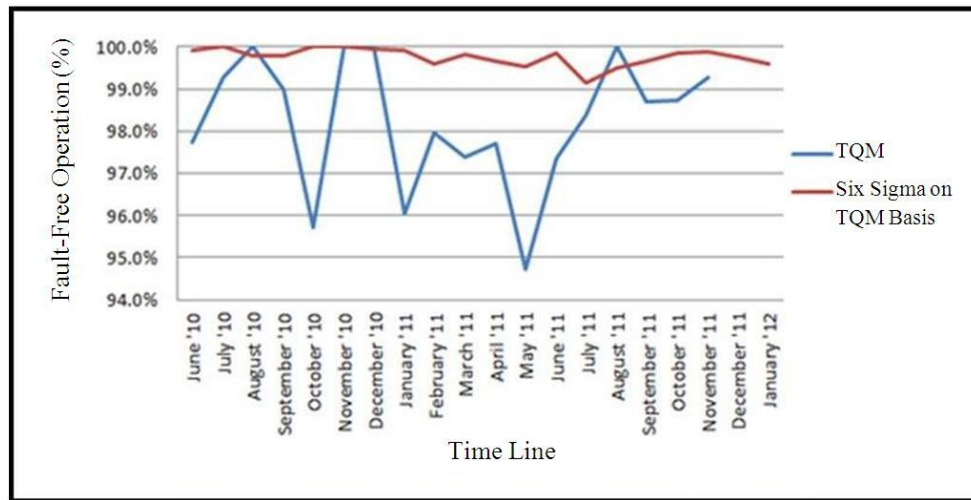


Figure 3 – A comparison of TQM and Six Sigma production lines

Conclusion

To conclude, the study has revealed that practising TQM in construction equipment manufacturing has been successful. However, the extent to which it will continue to improve quality can be questioned due to the large quality fluctuations; indicating that TQM may lose focus in time, thus supporting claim by McAdam et al. (2005).

It can be concluded that six sigma is a successful quality management approach within construction equipment manufacturing. However, Six Sigma has not yet managed to consistently achieve the company target of 100% fault-free operation. Therefore, this shows that there is room for improvement when using this approach.

Finally, it is the researcher's opinion that TQM should not be treated as a management fad due to the evidence of its success in improving quality. However, concluding the research findings and further discussion, it has to be said that Six Sigma has a faster and better record of effectiveness at improving quality. It is for this reason that the researcher believes Six Sigma should be introduced, using TQM as a roadmap, or foundation; and only once Six Sigma is firmly in place, should existing aspects of TQM be phased out (if necessary). In other words, TQM and Six Sigma should be seen as compliments, not substitutes, as both are required for a long-term success in quality management.

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References

- Aboelmaged, M.G. 2010. Six sigma quality: a structured review and implications for future research. *International Journal of Quality & Reliability Management* 27(3): 268-317.
- Albrecht, K. 1992. No eulogies for TQM. *The TQM Magazine* October: 271-272.
- Andersson, R., Eriksson, H., Torstensson, H. 2006. Similarities and differences between TQM, six sigma and lean. *The TQM Magazine* 18(3): 282-296.
- Antony, J. 2004. Some pros and cons of six sigma: an academic perspective. *The TQM Magazine* 16(4): 303-306.
- Antony, J. 2007. Is six sigma a management fad or fact? *Assembly Automation* 27(1): 17-19.
- Berquist, B., Fredriksson, M., Svensson, M. 2005. TQM: terrific quality marvel or tragic quality malpractice? *The TQM Magazine* 17(4): 309-321.
- Black, K., Revere, L. 2006. Six Sigma arises from the ashes of TQM with a twist. *International Journal of Health Care Quality Assurance* 19(3): 259-266.
- Bohan, G. 1998. Whatever happened to TQM? Or how a good strategy got a bad reputation. *National Productivity Review* 17(4): 13-16.
- Byrne, J.A. 1997. Commentary : Management Theory or Fad of the Month? *Bloomberg Business Week*. Available at <http://www.businessweek.com/stories/1997-06-22/commentary-management-theory-or-fad-of-the-month> (accessed date November 17, 2011).
- Central Intelligence Agency. 2010. The World Fact book: European Union. *Central Intelligence Agency*. Available at <https://www.cia.gov/library/publications/the-world-factbook/geos/ee.html> (accessed date November 27, 2011).
- Cheng, J.L. 2008. Implementing Six Sigma via TQM improvement: an empirical study in Taiwan. *The TQM Journal* 20(3): 182-195.
- Cheng, J.L. 2009. Six Sigma and TQM in Taiwan: An empirical study of discriminate analysis. *Total Quality Management* 20(3): 311-326.
- Dahlgaard, J.J., Dahlgaard-Park, S.M. 2006. Lean production, six sigma quality, TQM and company culture. *The TQM Magazine* 18(3): 263-281.
- Dahlgaard, J.J., Kristensen, K., Kanji, G.K. 1998. *Fundamentals of Total Quality Management*. Chapman & Hill, London.
- Dale, B.G. 1999. *Managing Quality*. Blackwell Publishers, Oxford.
- Department For Business Innovation And Skills. 2011. Manufacturing. *Department for Business Innovation and Skills*. Available at <http://www.bis.gov.uk/policies/business-sectors/manufacturing-and-materials/manufacturing> (accessed date November 29, 2011).
- Douglas, A. 2006. TQM is alive and well. *The TQM Magazine* 18(1):-.
- Ehigie, B.O., McAndrew, E.B. 2005. Innovation, diffusion and adoption of total quality management (TQM). *Management Decision* 43(6): 925-940.
- Evans, J.R., Lindsay, W.M. 2002. *The Management and Control of Quality*. Thomson, Cincinnati.
- Evans, R. 1995. Perspectives: In defence of TQM. *The TQM Magazine* 7(1): 5-6.
- Friedman, D. 2002. No Light at the End of the Tunnel. Los Angeles Times, 16 June.
- Goh, T.N., Xie, M. 2003. Statistical Control of a Six Sigma Process. *Quality Engineering* 15(4): 587-592.
- Maer, L. 2011. Manufacturing. *UK Parliament*. Available at <http://www.parliament.uk/briefing-papers/SN01942> (accessed date November 29, 2011).
- Green, F.B. 2006. Six-Sigma and the Revival of TQM. *Total Quality Management* 17(10): 1281-1286.
- Harry, M.J. 2000. A new definition aims to connect quality performance with financial performance. *Quality Progress* 33(1): 64-66.
- Hellsten, U., Klefsjo, B. 2000. Perspectives: TQM as a management system consisting of values, techniques and tools. *The TQM Magazine* 12(4): 238-244.
- Hoerl, R.W. 2001. Six Sigma Black Belts: What Do They Need to Know? *Journal of Quality Technology* 33(4): 391-406.
- Ingle, S., Roe, W. 2001. Six Sigma. Black Belt Implementation. *The TQM Magazine* 13(4): 273-280.
- Institute of Personnel Management., 1993. *Quality: People Management Matters*. Institute of Personnel Management, London.
- JCB, 2009. Story of JCB. *JCB*. Available at <http://www.jcb.com/promotions/storyofjcb/storyofjcb.aspx> (accessed date January 12, 2012).
- Kearney, A.T. 1992. *Total Quality: Time to Take off the Rose Tinted Spectacles*. IFS Publications, Kempston.
- Klefsjo, B., Bergquist, B., Edgeman, R. 2006. Six Sigma and Total Quality Management: different day, same soup? *International Journal of Six Sigma and Competitive Advantage* 2(2): 162-178.
- Klefsjo, B., Wiklund, H., Edgeman, R. 2001. Six Sigma seen as a methodology for Total Quality Management. *Measuring Business Excellence* 5(1): 31-35.

- Kolesar, P.J. 1995. Partial quality management: an essay. *Production and Operations Management* 4(3): 195-200.
- Lau, R.S.M., Anderson, C.A. 1998. A Three-Dimensional perspective of Total Quality Management. *International Journal of Quality & Reliability Management* 15(1): 85-98.
- Lemak, D., Reed, R. 1997. Commitment to total quality management: is there a relationship with firm performance? *Journal of Quality Management* 2(1): 67-86.
- Lucas, J.M. 2002. The essential of Six Sigma, *Quality Progress* 35(1): 27-31.
- McAdam, R., Hazlett, S.A., Henderson, J. 2005. A critical review of six sigma: exploring the dichotomies. *The International Journal of Organizational Analysis* 13(2): 151-174.
- Naslund, D. 2008. Lean, six sigma and lean sigma: fads or real process improvement methods? *Business Process Management Journal* 14(3): 269-287.
- Nonthaleerak, P., Hendry, L. 2008. Exploring the six sigma phenomenon using multiple case study evidence. *International Journal of Operations & Production Management* 28(3): 279-303.
- Oakland, J.S. 1993. *Total Quality Management*. Second Edition. Butterworth-Heinemann, Oxford.
- Pande, P.S., Neuman, R.P., Cavanach, R.R. 2000. *The Six Sigma Way*. McGraw-Hill, New York.
- Park-Dahlgaard, S.M. 2002. The human dimension in TQM – learning, training and Motivation. Linköping University Electronic Press, Linköping.
- Paton, S. 1994. Is TQM dead? *Quality Digest* 14(April): 1-5.
- Reed, M. 2000. Six Sigma eavesdropping on the Net!!!! *Quality Australia* 15(1): 10.
- Revere, L., Black, K. 2003. Integrating Six Sigma with Total Quality Management: A Case Example for Measuring Medication Errors. *Journal of Healthcare Management* 48(6): 377-391.
- Tennant, G. 2001. *Six Sigma: SPC and TQM in Manufacturing and Services*. Gower, Hampshire.
- Thawani, S. 2004. Six Sigma – strategy for organizational excellence. *Total Quality Management* 15(5-6): 655-664.
- Van Der Wiele, A., Williams, A.R.T., Dale, B.G. 2002. Total Quality Management: Is It a Fad, Fashion, or Fit? *Quality Management Journal* 7(2): 65-79.
- Yong, J., Wilkinson, A. 1999. The state of total quality management: a review. *The International Journal of Human Resource Management* 10(1): 137-161.