iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38357

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Systemic Review of Application of Six Sigma Approaches in Small and Medium Scale Industries: A Review in Respect of India

Neeru Yadav[1], Prof. (Dr.) Arun Patil[2]
[1, 2]*Amity University, Jaipur*

Abstract: ***Six Sigma is a tool which helps industries to control the defects and all other issues which can be possible factors to reduce the growth of the company. It was seen that in large scale industries, the Six Sigma is used form previous decades but when goes to small and medium scale industries, there is lack of implementation of Six Sigma and its tools, so in present review paper, various research papers selected in which small and medium scale industries are selected. In this paper all possible aspects of the Six Sigma is presented in detail.***
Keywords: Six Sigma, Tools, Small Scale Industries, DMAIC approach, Manufacturing Industries

I. INTRODUCTION

During the most recent sixty years past, industries are turning out to be profoundly quality cognizant to confront the expanding more than other competitor industry. In this specific situation, apparatuses like SPC (Statistical Process Control, ISO ISO quality norms, QMSs (Quality Management Systems), QCs (Quality Circles), benchmarking, TQM (Total Quality Management), Bench Marking and so forth have made a huge effect on manufacturing associations. Quality architects have begun following the 'Keep it Simple' equation for execution assessment with an end goal to improve the performance of their industries. Devices for quality and procedures are being applied diversely in present dynamic, unstable and competitive industrial climate. It is known to all that practically every one of the strategies for manufacturing and related measures will undoubtedly have fluctuation. These various varieties happening in the measures are separated into two kinds, ie. ones on account of internal/normal causes, also, others because of exceptional reasons. Previous is called unavoidable causes liable for varieties being innate to the cycle. These reasons bring about a dissemination of qualities which shows up as practically ordinary and unsurprising. The other arrangement of varieties is a direct result of certain particular causes being because of certain unique causal effects all the while or in the existing climate. Be that as it may, for the endurance and financial feasibility of any industry, its presentation as far as manufacturability should be improved. Due to the ceaselessly rising populace, higher interest trouble, rising expansion, declining GDP it is very critical to be serious for enterprises in nations like India.

Industries have various targets like further developed limit usage, accomplishing productivity just as immaterial targets of consumer loyalty and cultural administrations. Assets are used as contributions to accomplish these targets. Six Sigma is rehearsed as a philosophical interaction and furthermore rehearsed as a technique to upgrade quality by examination of the information with insights for becoming more acquainted with the essential drivers of quality issues and to execute controls (Aboelmaged 2010; Aggogeri, and Gentili 2008; Al-Mishari, and Suliman 2008). However Six Sigma is generally utilized in manufacturing enterprises, yet it can be viably utilized in any remaining various cycles being managed in by different business associations

The most general technique Continuous Improvement (CI) began in nineteenth century. In any association CI is made and executed with some worldview to a proceeded period to acquire efficiency, increment piece of the productivity, client certainty and improve brand esteem and to get by on the lookout. CI techniques make new system and substitute technique to acquire productivity in the current model and change business activity to make benefit. Old crude techniques like lean, kanban, total quality management(TQM), just in time(JIT), six sigma and complete useful administration (TPM) are utilized for foreordained improvement to make measure execution simpler. Likewise, standard intelligent calculations and strategies like fluffy rationale, neural networks, man-made reasoning and so on are lined up with old crude strategies. Coordination of these strategies is the best way to deal with meet functional necessities Maybe than developing another strategy and strategies (Ehie and Sawhney, 2005). It is distinguished that execution of Lean, Six Sigma and Theory of Limitations (TOL) independently or mix of these strategies will yield a better outcome. Lean standards accentuate the disposal of stowed away waste from a creation framework to make it all around organized. Distinguishing the secret waste can be arranged as waste from over creation, transportation waste

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

A. Definitions-Six Sigma

Six Sigma(6σ) is a sequence of procedure implemented with certain tools to improve the process. It was suggested by Bill Smith & Mikel J Harry in association with Motorola in the year 1986. Jack Welch implemented to his operation strategy at General Electric in the year 1995. (Ehie and Sawhney, 2005) Six Sigma improves the quality and reduces variance of the system. The output of a process can be improved by identifying, removing defects and suggesting alternate plans in manufacturing and business operation. Implement sequence of procedure on quality control procedures, empirical formula, statistical approaches and five stages of instructions for the resource within the system. Every six sigma project executed within a company should follow a sequence of procedural steps and has specific value. The aim of executing the procedure is to reduce operation cycle time, variance, cost, improve customer feedback and profit. The Six Sigma is registered as a Motorola trademark on 28th Dec 1993. Root origin is originated from statistics. The robust manufacturing setup and process can be described by a sigma outcome indicating its quality or the percentage of accuracy it creates. By implementing six sigma procedures the products are as accurate as 99.99966%. All the products produced with some feature are expected to be high quality with negligible defects and six sigma allows 3.4 defective parts per million. Motorola set a target achievement of 3.4 defective parts per million for all the products manufactured from their subsidiary units and this goal became a top priority for the management.

1) Step-I: Application of Statistics for implementation of Six Sigma

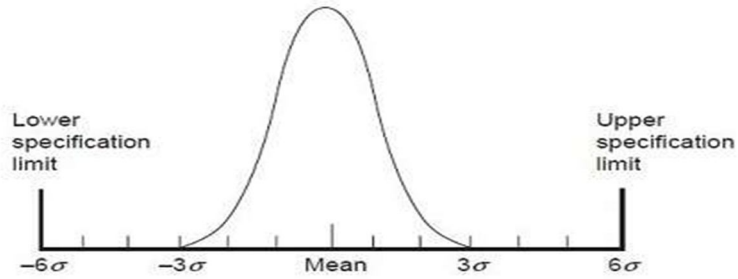


Figure 1.1 3-sigma and 6-sigma definitions

Hongbo Wang (2008) states that, based on statistics, Six Sigma basically refers to that
process, where range between mean of the quality of the process and the existing nearest specification limit, is minimum six times of the SD (standard deviation) of the process

2) Step-II: Six Sigma in respect of management point of View
3) Step-III: Six Sigma with combined effect of Step-I and Step-II
a) Define, Measure Analyze, Improve and Control(DMAIC)
b) Define, Measure, Analyze, Design and Verify(DMADV)

B. DMAIC

1) Define: The define phase is about understanding the existing operation, voice of the customer, major requirements in the system and customers expectations.
2) Measure: The measure phase is to determine the key parameters of the existing 'as is' process, measure relevant data and determine the current process capability.
3) Analyze: The analyze phase is to investigate the data and verify input to outcome of the system relationship. Data processing, data analyse and interpretation of the parameters is also considered. Try to find root cause of the variance and errors within the system.
4) Improve: The improve phase is to streamline the existing procedure based on the outcome of data processing and interpretation of the results. Design of experiments, standard workflow procedures and future state layout are the improvement methods.
5) Control: The control phase suggests the future change in process and ensures the process is not violated to get the desired output and the process is checked before the end result. Implementing robust systems like statistical analysis, visual checking in process and automatic system to check the process. This control phase is repeated in loop and checked till the optimum quality is obtained.

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

II. SIX SIGMA TOOLS

Tools required for Six Sigma implementation are present here, these tools help to find the outcome form Six Sigma techniques. For each stage different tools are required for Six Sigma methods

1) *Step-I Define*
   - VOC Tools
   - Process mapping
   - Project Charter
   - SIPOC
   - QFD
   - benchmarking

2) *Step-II Measure*
   - Data reducing and mining
   - Pareto Charts
   - Run Analysis
   - Exploratory data analysis
   - Descriptive statistics

3) *Step-III Analyze*
   - Fish Bone Diagram (Cause and Effect)
   - Tree diagram
   - DOE
   - Enumeration statistics
   - FMEA
   - Simulation, ANOVA

4) *Step-IV Improve*
   - Force field diagram
   - 7M tools
   - Prototype Pilot Studies

5) *Step-V Control*
   - SPC
   - FMEA
   - Reporting system

A. Six Sigma for Manufacturing Sector

All associations are having their own shortcomings just as qualities. Six Sigma as a methodology helps in such a circumstance in assisting an association with investigating itself. A large number of the shortcoming will arise just during the execution of Six Sigma as an improvement method. According to Charles Waxer (2004); at whatever point there is a conversation on simplicity of execution of Six Sigma just as requirements inside an association; it is normally seen that little associations enjoy certain benefits just as disservices. These little associations are more light-footed, more adaptable and more versatile. Yet, their requirements may be helpless admittance to prepared belts or significantly lesser information on Six Sigma when contrasted with colossal foundation and assets of large associations. A little association has numerous a choice to deal with the expense of preparing, cost to employ a specialist for doing preparing furthermore, to organize various advisors for giving master exhortation on the particular task. Larg enterprises have, ordinarily, arrangements for Six Sigma preparing of not just their faculty yet additionally their providers, retailers, clients just as their providers. As of late, limited scope enterprises have accepted a vital job in India,s economy. These are assuming a significant part in the financial and mechanical advancement of our country. These little enterprises are a major wellspring of work age and record for a significant offer in the fares by the country (Verma 2010).

©IJRASET: All Rights are Reserved

Six Sigma was presented by Motorola, and in Six Sigma was presented by Motorola, and in exceptionally brief time frame it was presented in numerous manufacturing yet the issue actually exists how to apply it in little and medium scaled businesses. The proof of Six Sigma application in little and medium scaled businesses are very little. Solely after the utilization of Six Sigma improvement drive the qualities furthermore, troubles of associations can be recognized and can be eliminated. According to Kulkarni (2002); little and medium enterprises are assuming a critical part in the improvement of the country. Their commitment in generally GDP of the country is around 40 percent, while commitment in public fares is very nearly 50%. Their part in work age and local improvement of the country is enormous and calls for progressive strides to work on this area. Small enterprises are the ones who feel the most extreme warmth during financial breakdowns or other monetary issues confronting the country. Six Sigma has a vital task to carry out in the future to moderate the various issues being looked by the country. Prior it was imagined that Six Sigma comes in the domain of just the enormous associations, however this was only a bogus impression and in later times, this thought has been refuted. Little enterprises face an absence of assets to execute Six Sigma. To new business objectives and targets; every association should utilize apparatuses to confront the contest and accomplish development in the present carefully old age.

B. Research Papers Selection for Present Study

In present chapter various key issues are identifies regrading application of Six-Sigma methods for reducing the production time and failure of new product at small and medium scale industries. In present chapter, the research papers selected for review are divided in various sections which are following:

1) Definitions of Six Sigma
2) Various Factors involved in Six Sigma
3) Six Sigma Application in Manufacturing Industries
4) Tools used for Six Sigma implementations

To complete the literature review various digital mediums are used for this chapter

C. Main Source of finding is Research Paper

Science Direct Data base,
Taylor & Francis,
Springer,
Inderscience and
Emerald etc.

D. Main Source of Finding Dissertations & Theses

MIT ocw e-theses,
ProQuest,
British Library EThOS ,
NCSU-Digital Repository, Shodhganga, NIT and IIT database

E. Main Keywords for Present Review Papers

Six Sigma
Six Sigma in small and medium scale industries
Six Sigma Tools
DMAIC methodology
Six Sigma in manufacturing industries
Six Sigma and management Tools integration
Lean Six Sigma application
Others

F. Six Sigma General Definitions

The Six-Sigma idea was started in acknowledgment of the fast changes in innovation. With the profoundly computerized cycles of today, lenience of non-conformance is required to be more tight (Productivity Tools, 2005). It has been shown that Six-Sigma is a fruitful system for decreasing problems and further developing efficiencies of assortment of utilizations including fabricating,

©IJRASET: All Rights are Reserved

designing activity, and medical services (Revere, 2000). Six-Sigma depends on factual interaction control ideas and, consequently, utilizes sigma estimation in guaranteeing conformance to details (Bendell, 2000). At the point when an association chooses to execute Six Sigma, it's proposed that there are three potential entrances, or approaches. The first is a business change approach at which an association chooses a full-scale change drive to end away from old propensities, recapture lost clients, and recuperate from hefty misfortunes. With this methodology, all key cycles are analyzed to make suggestions for change. The second is vital improvement approach which can be restricted to a couple of basic business needs, with groups and preparing pointed toward tending to significant freedoms and shortcomings. The third is a critical thinking approach which targets just annoying and persevering issues. This methodology is best for organizations that need to take advantage of the advantages of Six-Sigma without significant change in the association (Pande and Holpp, 2002). When a methodology is chosen, a group comprised of an assortment of business pioneers, colleagues, group pioneers, and facilitators is graphed. A few jobs may have material expressions names like Black Belt (BB), Green Belt (GB), Master Black Belts (MBB). BBs are liable for driving and finishing projects, showing colleagues on the procedure, and tutoring GBs. GBs are prepared in a subset of the strategy to help BBs or to deal with little degree projects. MBBs are master in the devices and they give instructing to BBs and GBs. Champions select significant undertakings, offer all strategic help, and guarantee the force is maintained. Cycle proprietors take responsibility for project when finished and keep up with venture's benefits. They likewise eliminate obstructions for BBs. Money champions set up clear standards on hard and delicate reserve funds as well as assessing and guaranteeing project reserve funds (Six Sigma Academy, 2002). Six-Sigma utilizes a five-venture measure known as DMAIC representing characterize, measure, examine, improve, and control. Components influencing execution are characterized on which quality information is estimated. With escalated utilization of insights, the deliberate information is broke down to build up factual relationship among's deformities and potential underlying drivers.

Some advantages and limitations found by researchers on Six Sigma for manufacturing industries are summarized in table 2.1 which is following:

Table 1 Pros and Cons of Six Sigma modeling technique

Author Name	Sector for Case Study	Pros and Cons
Salman T. Al-Mishari	Service Industry	Six Sigma can be used with reliability improvement methods (RCM) easily but for Six sigma rich data is mandate, which is sometime not available
Alireza Shokri	Small Scale manufacturing	This paper findings suggests that Lean Six Sigma can be used for small scale industries also, No Cons Discussed
Ayon Chakrabarty	Service Industry	Implementation of Six Sigma in service industry is beneficial but the lack of data is main key issue for Six Sigma
Ike Ehie	Gear Manufacturing Industry	Six Sigma can be used with theory of constraints (TOC) to improve the result quality, No Cons Discussed
RAJ BARDHAN ANAND	deep drawing manufacturing Industry	Six Sigma can reduce the defects and operational issues with RSM technique, No cons discussed
Roy Andersson	General Study	Discuss advantages of Six Sigma over TQM and Lean, the main issues with these techniques are data collection
Gustavo Franco Barbosa	aircraft painting shop	Cost of manufacturing can be reduced by using the Six Sigma technique, No cons discuss
Arto Haikonen	Service Industry	Six Sigma can be used for improvement of managerial work, No Cons Discuss
E. A. E. Osore	Sugar Cane manufacturing Industry	By application of Six Sigma faster production can be achieved by industries, but data collection is main parameter for better study
Jiju Antony	medium-sized UK manufacturing enterprises	For medium scale industries, Six sigma is useful tool to reduce the defects and increase the productivity

©IJRASET: All Rights are Reserved

Conveying the two methodologies in various pieces of the business at the same time is conceivable, regardless of whether a large portion of the distributions audited introduced the contextual investigations dependent on both of them. As an overall pattern, numerous associations have now stretched out DMAIC to incorporate DFSS (Mader, 2006). Conceivable explanation is that numerous organizations commonly train their workers in DMAIC first then, at that point extend it to DFSS which is customized to the setting of new item as well as administration advancement. In this regard, Banuelas and Antony (2004) expressed that to accomplish the Six Sigma figure of 3.4 PPM of deformities is to overhaul items, key cycles and administrations through DFSS. This contention is, in any case, easy to refute as no writing unmistakably acknowledges or dismisses this theory. Regardless, Edgeman and Dugan (2008) contend that both DMAIC and DFSS are solidly established in the logical strategy and are from multiple points of view similar to the natural methodologies utilized either by the speculation testing or the iterative trial plan. The writing further shows that there are a few varieties for DMAIC (regardless of whether it stays the most generally embraced system) like Project-DMAIC (P-DMAIC), Enterprise-DMAIC (E-DMAIC) and DMAIC Report (DMAICR). The distinctions are for the most part as far as the number and kind of phases, as opposed to the apparatuses utilized. DMAICR, for example, adds the last advance of "announcing the advantages of the re-designed interaction" into DMAIC (Senapati, 2004). Various varieties of DFSS likewise exist, for instance, characterize measure dissect configuration confirm (DMADV), plan describe enhance check (DCOV), recognize configuration streamline approve, distinguish portray advance confirm and DMADV, however for this situation, there are no huge contrasts among them. The choice of the technique, eventually, relies upon the particular prerequisites (Chakrabarty and Tan, 2007) and a few organizations carry out Six Sigma at the task level as well as at the endeavor level (Ward et al., 2008). In these occasions, either P-DMAIC or E-DMAIC approach is by and large utilized (Breyfogle, 2008). Watson and deYong (2010) give a far reaching ordered elective ways to deal with DFSS.

G. Various Factors Involved in Six Sigma

Numerous devices and procedures that can be applied to Six Sigma projects are accessible both in the writing and public area, for example Halliday (2005). Albeit the greater part of these devices are now notable and applied in different settings, Six Sigma gives a client zeroed in, distinct philosophy upheld by an unmistakable arrangement of thorough devices for measure improvement (van Iwaarden et al, 2008). Essential instruments of DMAIC, ordinarily utilized at the Yellow-Belt level of ability incorporate flowcharts, check sheets, Pareto graphs, cause/impact outlines, disperse charts, histograms and Statistical Process Control (Ferrin et al, 2005). Further developed devices like relapse analysis (for example with marker factors, curvilinear relapse and strategic relapse), speculation testing, control graphs and Design of Experiments commonly include at the Black-Belt level. This likewise implies Six Sigma might be seen as a blend of existing devices and procedures accessible well before Motorola fostered this methodology (van Iwaarden et al, 2008).

H. Six Sigma in Manufacturing Industries

Hsiang-Chin Hung and Ming-Hsien Sung (2011) has utilized The DMAIC (characterize measure-investigate improve-control) approach in food organization in Taiwan. By this technique he tackled a fundamental issue of diminishing interaction variety . consequently he could lessen high deformity rate related with it. The outcomes acquired were the decreased deformity pace of little custard buns by 70% from the pattern to its qualification. He has additionally introduced thought in regards to the variables that are answerable for achievement of Six Sigma project in a food industry. Prof. Dr. Vidosav MAJSTOROVIĆ, et. al (2010) [9] in his work has utilized DMAIC methodolgy in certain Serbian metal preparing producing organization. What He accomplished through his task was the decrease of interaction inconstancy, hence diminishing amount of dissentions item. It prompted increment of Sigma Level for the noticed assembling framework/interaction and consumer loyalty.

Mohit taneja (2013) has utilized Six Sigma Approach to Improve Productivity in Manufacturing Industry. In his paper he starts with an outline of Six Sigma, trailed by exhaustive writing audit on Six Sigma DMAIC phases, utilization of Six Sigma in little medium scale businesses and furthermore in enormous assembling enterprises. He has likewise done writing overview on different Six Sigma quality apparatuses utilized in the businesses. These incorporate Process ability analysis, Fishbone Diagram, Two-example t-test. Tushar N Desai and Dr. R L shrivastava (2008) , in their paper they have talked about the quality and efficiency improvement in an assembling endeavor through a contextual investigation. The paper manages a use of Six Sigma DMAIC philosophy in an industry which gives a structure to recognize, evaluate and take out wellsprings of variety in a functional interaction being referred to, to streamline the activity factors, improve and support execution viz. measure yield with top notch control plans. The interaction yield was improved because of executing this strategy. It has impact of improved and better use of assets and diminished varieties. It additionally helped in keeping up with reliable quality of the interaction yield.

©IJRASET: All Rights are Reserved

Lateef Ur Rehman, Ateekh-ur-Rehman (2012) have utilized Six Sigma Approach For a Safety Management in a Manufacturing Company. There was a wellbeing and security office at the assembling office in the focussed organization and its goal was to set and further develop mishaps avoidance framework. The paper presents how the six-sigma strategy will assist with assessing the security and natural perils in execution of associations. The target of this investigation is to utilize six-sigma procedure to recognize and decrease the events of mishaps at the organization in thought.

Dr. Rajeshkumar U. Sambhe (2012), in his paper has zeroed in on average sized auto auxiliary unit comprising of 350-400 worker and utilized Six Sigma procedures to lift towards the fantasy of Six Sigma quality level. The philosophy is executed on one of item gathering for managing down absconds level which are basic to clients and its execution has had a critical monetary arrived in a desperate predicament line of the endeavor. In characterize phase he created project contract and afterward characterized Opportunity articulation and objective explanation.

Rajeshkumar U. Sambhe and Dr. Rajendra S. Dalu (2011) have assessed Six Sigma execution in medium scale Indian auto undertakings. In this paper they have talked about basic achievement factors for effective Six Sigma execution in medium scale auto ventures in India. The review was directed utilizing the survey technique. Their finishing up comments are there is next to no exploration completed in car area and the investigation tracks down that just a 25.64% of medium scale car area has executed Six Sigma. They additionally expressed that Medium Scale Automotive Enterprises are having acceptable establishment of ISO 9000 .they likewise asserted that numerous undertakings have begun receiving other great quality administration systems like Kaizen and TPM.

III. LIMITATIONS IDENTIFIED BY USING LITERATURE REVIEW

It was seen that the disappointment pace of Six Sigma is extremely high, with regards to other hierarchical change drives. This first impediment is seen as a significant examination hole for organizations quick to put resources into Six Sigma drives. For example, Glasgow et al. (2010) and Albliwi et al. (2014) report that more than 60% of Six Sigma drives neglected to convey the wanted outcomes. Like some other quality improvement drive, Six Sigma gets going great; however neglects to have an enduring effect after some time. Subsequently, inspiration and energy drop, and associations fall once more into old propensities (Chakravorty, 2005). A few examinations show that around 60% of all corporate Six Sigma drives fizzle (Angel and Pritchard, 2008; Chakravorty, 2009a, b, 2010). It is assessed that right around 70% of progress the board drives in associations come up short (Beer and Nohria, 2000; Hughes, 2011), like Six Sigma at around 60–70 percent (Spector and Beer, 1994; Hughes, 2011; Pedersen and Huniche, 2011; Bhasin, 2012). Because of these disappointments, more organizations across different industry areas are pulling back on their Six Sigma drives. It is felt that the philosophy alone isn't a cureall for corporate ills (Angel and Pritchard, 2008; Chakravorty, 2009b). This presents a reasonable hole in comprehension around the explanations behind disappointments and a need to create therapeutic systems to moderate future disappointments.

IV. CONCLUSION

After review of the various research works on Six Sigma specially DMAIC method, some important conclusions are found out which are following:

A. After review of various research papers, most of the researchers work on now in small scale industries to improve their working environments.

B. Most of the researchers use the DMAIC tool for apply the Six Sigma in small and medium scale industries.

C. Like other tools Six Sigma has also some limitations so during research some take care required for better analysis using Six Sigma DMAIC tool.

REFERENCES

[1] Al-Mishari, S. T., & Suliman, S. (2008). Integrating Six-Sigma with other reliability improvement methods in equipment reliability and maintenance applications. Journal of Quality in Maintenance Engineering, 14(1), 59–70. https://doi.org/10.1108/13552510810861941

[2] Anand, R. B., Shukla, S. K., Ghorpade, A., Tiwari, M. K., & Shankar, R. (2007). Six sigma-based approach to optimize deep drawing operation variables. International Journal of Production Research, 45(10), 2365–2385. https://doi.org/10.1080/00207540600702308

[3] Andersson, R., Eriksson, H., & Torstensson, H. (2006). Similarities and differences between TQM, six sigma and lean. TQM Magazine, 18(3), 282–296. https://doi.org/10.1108/09544780610660004

[4] Antony, J., Kumar, M., & Tiwari, M. K. (2005). 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, 219(8), 633–646. https://doi.org/10.1243/095440505X32418

[5] Antony, J., Kumar, M., & Madu, C. N. (2005). Six sigma in small- and medium-sized UK manufacturing enterprises: Some empirical observations. International Journal of Quality and Reliability Management, 22(8), 860–874. https://doi.org/10.1108/02656710510617265

©IJRASET: All Rights are Reserved

[6] Arnheiter, E. D., & Maleyeff, J. (2005). The integration of lean management and Six Sigma. The TQM Magazine, 17(1), 5–18. https://doi.org/10.1108/09544780510573020
[7] Barbosa, B., Pereira, M. T., Silva, F. J. G., & Campilho, R. D. S. G. (2017). Solving Quality Problems in Tyre Production Preparation Process: A Practical Approach. Procedia Manufacturing, 11(June), 1239–1246. https://doi.org/10.1016/j.promfg.2017.07.250
[8] Barbosa, G. F., de Carvalho, J., & Pereira de Souza, C. H. (2014). Deployment of a laser projection solution for stripes plotting based on Six Sigma DMAIC methodology applied to aircraft painting shop. Production and Manufacturing Research, 2(1), 697–711. https://doi.org/10.1080/21693277.2014.943432
[9] Bauelas, R., & Antony, J. (2004). Six sigma or design for six sigma? TQM Magazine, 16(4), 250–263. https://doi.org/10.1108/09544780410541909
[10] Bhanpurkar, A., Bangar, A., Goyal, S., & Agrawal, P. (2012). Implementation of Six Sigma Program for Lean Manufacturing "To reduce the rework waste in Transformer manufacturing unit by eliminating defect of leakage from bushings in oil filled transformers. International Journal of Mechanical and Industrial Engineering, 1(3), 197–202. https://doi.org/10.47893/ijmie.2012.1039
[11] Bhanpurkar, A., Bangar, A., Goyal, S., & Agrawal, P. (2012). Implementation of Six Sigma Program for Lean Manufacturing "To reduce the rework waste in Transformer manufacturing unit by eliminating defect of leakage from bushings in oil filled transformers. International Journal of Mechanical and Industrial Engineering, 2231, 197–202. https://doi.org/10.47893/ijmie.2012.1039
[12] Bunce, M. M., Wang, L., & Bidanda, B. (2008). Leveraging Six Sigma with industrial engineering tools in crateless retort production. International Journal of Production Research, 46(23), 6701–6719. https://doi.org/10.1080/00207540802230520
[13] Chakrabarty, A., & Tan, K. C. (2007). The current state of six sigma application in services. Managing Service Quality, 17(2), 194–208. https://doi.org/10.1108/09604520710735191
[14] Chen, S., Fan, S., Xiong, J., & Zhang, W. (2017). The Design of JMP/SAP Based Six Sigma Management System and its Application in SMED. Procedia Engineering, 174, 416–424. https://doi.org/10.1016/j.proeng.2017.01.161
[15] Chung, Y. C., Hsu, Y. W., & 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 and Business Excellence, 19(6), 595–607. https://doi.org/10.1080/14783360802024408
[16] Costa, J. P., Lopes, I. S., & Brito, J. P. (2019). Six Sigma application for quality improvement of the pin insertion process. Procedia Manufacturing, 38(2019), 1592–1599. https://doi.org/10.1016/j.promfg.2020.01.126
[17] Costa, L. B. M., Godinho Filho, M., Fredendall, L. D., & Ganga, G. M. D. (2020). The effect of Lean Six Sigma practices on food industry performance: Implications of the Sector's experience and typical characteristics. Food Control, 112(January), 107110. https://doi.org/10.1016/j.foodcont.2020.107110
[18] Cunha, C., & Dominguez, C. (2015). A DMAIC Project to Improve Warranty Billing's Operations: A Case Study in a Portuguese Car Dealer. Procedia Computer Science, 64(00351), 885–893. https://doi.org/10.1016/j.procs.2015.08.603
[19] Davison, L., & Al-Shaghana, K. (2007). The link between six sigma and quality culture - An empirical study. Total Quality Management and Business Excellence, 18(3), 249–265. https://doi.org/10.1080/14783360601152269
[20] Desai, D. A., Kotadiya, P., Makwana, N., & Patel, S. (2015). Curbing variations in packaging process through six sigma way in a large-scale food-processing industry. Journal of Industrial Engineering International, 11(1), 119–129. https://doi.org/10.1007/s40092-014-0082-6
[21] Ehie, I., & Sheu, C. (2005). Integrating six sigma and theory of constraints for continuous improvement: A case study. Journal of Manufacturing Technology Management, 16(5), 542–553. https://doi.org/10.1108/17410380510600518
[22] Erbiyik, H., & Saru, M. (2015). Six Sigma Implementations in Supply Chain: An Application for an Automotive Subsidiary Industry in Bursa in Turkey. Procedia - Social and Behavioral Sciences, 195, 2556–2565. https://doi.org/10.1016/j.sbspro.2015.06.447
[23] Ertürk, M., Tuerdi(Maimaitiaili. Tuerdi), M., & Wujiabudula, A. (2016). The Effects of Six Sigma Approach on Business Performance: A Study of White Goods (Home Appliances) Sector in Turkey. Procedia - Social and Behavioral Sciences, 229, 444–452. https://doi.org/10.1016/j.sbspro.2016.07.154
[24] Fahey, W., Jeffers, P., & Carroll, P. (2020). A business analytics approach to augment six sigma problem solving: A biopharmaceutical manufacturing case study. Computers in Industry, 116, 103153. https://doi.org/10.1016/j.compind.2019.103153
[25] Furterer, S., & Elshennawy, A. K. (2005). Implementation of TQM and Lean Six Sigma tools in local government: A framework and a case study. Total Quality Management and Business Excellence, 16(10), 1179–1191. https://doi.org/10.1080/14783360500236379
[26] Gaikwad, L. M., Sunnapwar, V. K., Teli, S. N., & Parab, A. B. (2019). Application of DMAIC and SPC to Improve Operational Performance of Manufacturing Industry: A Case Study. Journal of The Institution of Engineers (India): Series C, 100(1), 229–238. https://doi.org/10.1007/s40032-017-0395-5
[27] Gijo, E. V., & Scaria, J. (2014). Process improvement through Six Sigma with Beta correction: A case study of manufacturing company. International Journal of Advanced Manufacturing Technology, 71(1–4), 717–730. https://doi.org/10.1007/s00170-013-5483-y
[28] Girmanová, L., Šolc, M., Kliment, J., Divoková, A., & Mikloš, V. (2017). Application of Six Sigma Using DMAIC Methodology in the Process of Product Quality Control in Metallurgical Operation. Acta Technologica Agriculturae, 20(4), 104–109. https://doi.org/10.1515/ata-2017-0020
[29] Gupta, V., Jain, R., Meena, M. L., & Dangayach, G. S. (2018). Six-sigma application in tire-manufacturing company: a case study. Journal of Industrial Engineering International, 14(3), 511–520. https://doi.org/10.1007/s40092-017-0234-6
[30] Haikonen, A., Savolainen, T., & Järvinen, P. (2004). Exploring Six Sigma and CI capability development: Preliminary case study findings on management role. Journal of Manufacturing Technology Management, 15(4), 369–378. https://doi.org/10.1108/17410380410535071
[31] Indrawati, S., & Ridwansyah, M. (2015). Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application. Procedia Manufacturing, 4(Iess), 528–534. https://doi.org/10.1016/j.promfg.2015.11.072
[32] Ishak, A., Siregar, K., Asfriyati, & Naibaho, H. (2019). Quality Control with Six Sigma DMAIC and Grey Failure Mode Effect Anaysis (FMEA): A Review. IOP Conference Series: Materials Science and Engineering, 505(1), 0–8. https://doi.org/10.1088/1757-899X/505/1/012057
[33] Ismail, A., Mohamed, S. B., Juahir, H., Toriman, M. E., Kassim, A. M., Zain, S. M., Ahmad, W. K. W., Fah, W. K., Retnam, A., Mokhtar, M., Zali, M. A., Taib, M. Z. M., & Yang, C. (2018). DMAIC Six Sigma methodology in petroleum hydrocarbon oil classification. International Journal of Engineering and Technology(UAE), 7(3.14 Special Issue 14), 98–106. https://doi.org/10.14419/ijet.v7i3.14.16868
[34] Jevgeni, S., Eduard, S., & Roman, Z. (2015). Framework for continuous improvement of production processes and product throughput. Procedia Engineering, 100(January), 511–519. https://doi.org/10.1016/j.proeng.2015.01.398

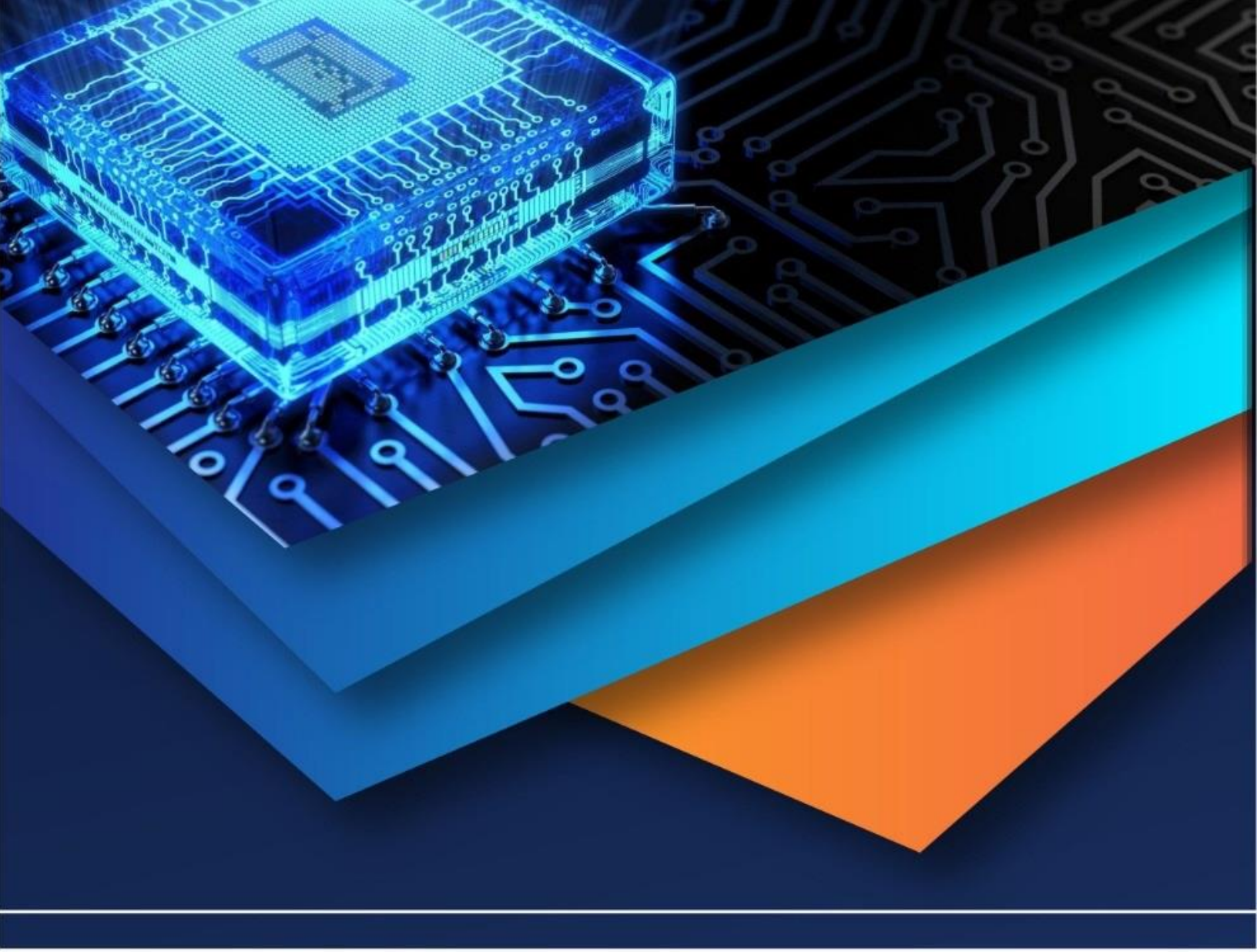
©IJRASET: All Rights are Reserved

[35] Jirasukprasert, P., Garza-Reyes, J. A., & Kumar, V. & Lim, M. K. (2014). A Six Sigma and DMAIC Application for the Reduction of Defects in a Rubber Gloves Manufacturing Process. International Journal of Lean Six Sigma, 5(1), 2–21.
[36] Kaid, H., Noman, M. A., Nasr, E. A., & Alkahtani, M. (2016). Six Sigma DMAIC phases application in Y company: a case study. International Journal of Collaborative Enterprise, 5(3/4), 181. https://doi.org/10.1504/ijcent.2016.082330
[37] Latessa, I., Fiorillo, A., Picone, I., Balato, G., Trunfio, T. A., Scala, A., & Triassi, M. (2021). Implementing fast track surgery in hip and knee arthroplasty using the lean Six Sigma methodology. The TQM Journal, 33(7), 131–147. https://doi.org/10.1108/tqm-12-2020-0308
[38] Lighter, D. E. (2014). The application of Lean Six Sigma to provide high-quality, reliable pediatric care. International Journal of Pediatrics and Adolescent Medicine, 1(1), 8–10. https://doi.org/10.1016/j.ijpam.2014.09.009
[39] Mehrabi, J. (2012). Application of Six-Sigma in Educational Quality Management. Procedia - Social and Behavioral Sciences, 47, 1358–1362. https://doi.org/10.1016/j.sbspro.2012.06.826
[40] Nedeliaková, E., Štefancová, V., & Kudláč, Š. (2017). Six Sigma and Dynamic Models Application as an Important Quality Management Tool in Railway Companies. Procedia Engineering, 187, 242–248. https://doi.org/10.1016/j.proeng.2017.04.371
[41] Costa, T., Silva, F. J. G., & Pinto Ferreira, L. (2017). Improve the extrusion process in tire production using Six Sigma methodology. Procedia Manufacturing, 13, 1104–1111. https://doi.org/10.1016/j.promfg.2017.09.171
[42] Dasgupta, T. (2003). Using the six-sigma metric to measure and improve the performance of a supply chain. Total Quality Management and Business Excellence, 14(3), 355–366. https://doi.org/10.1080/1478336032000046652
[43] De Mast, J., & Lokkerbol, J. (2012). An analysis of the Six Sigma DMAIC method from the perspective of problem solving. International Journal of Production Economics, 139(2), 604–614. https://doi.org/10.1016/j.ijpe.2012.05.035
[44] Hill, J., Thomas, A. J., Mason-Jones, R. K., & El-Kateb, S. (2018). The implementation of a Lean Six Sigma framework to enhance operational performance in an MRO facility. Production and Manufacturing Research, 6(1), 26–48. https://doi.org/10.1080/21693277.2017.1417179
[45] Wang, X., Wen, D., Wang, W., Suo, M., & Hu, T. (2019). Application of biological variation and six sigma models to evaluate analytical quality of six HbA1c analyzers and design quality control strategy. Artificial Cells, Nanomedicine and Biotechnology, 47(1), 3598–3602. https://doi.org/10.1080/21691401.2019.1642207
[46] Ricciardi, C., Balato, G., Romano, M., Santalucia, I., Cesarelli, M., & Improta, G. (2020). Fast track surgery for knee replacement surgery: a lean six sigma approach. TQM Journal, 32(3), 461–474. https://doi.org/10.1108/TQM-06-2019-0159
[47] Ricciardi, C., Sorrentino, A., Improta, G., Abbate, V., Latessa, I., Perrone, A., Triassi, M., & Dell'aversana Orabona, G. (2020). A health technology assessment between two pharmacological therapies through Six Sigma: the case study of bone cancer. TQM Journal, 32(6), 1507–1524. https://doi.org/10.1108/TQM-01-2020-0013
[48] Sánchez-Rebull, M. V., Ferrer-Rullan, R., Hernández-Lara, A. B., & Niñerola, A. (2020). Six Sigma for improving cash flow deficit: a case study in the food can manufacturing industry. International Journal of Lean Six Sigma, 11(6), 1119–1140. https://doi.org/10.1108/IJLSS-12-2018-0137
[49] Naeem, K., Ullah, M., Tariq, A., Maqsood, S., Akhtar, R., Nawaz, R., & Hussain, I. (2016). Optimization of steel bar manufacturing process using six sigma. Chinese Journal of Mechanical Engineering (English Edition), 29(2), 332–341. https://doi.org/10.3901/CJME.2015.1225.155
[50] Kumaravadivel, A., & Natarajan, U. (2013). Application of Six-Sigma DMAIC methodology to sand-casting process with response surface methodology. International Journal of Advanced Manufacturing Technology, 69(5–8), 1403–1420. https://doi.org/10.1007/s00170-013-5119-2
[51] Nowotarski, P., Szymanski, P., & Rzepecka, P. (2019). DMAIC Method of Quality Improvement of Ground Works Processes: Case Study. IOP Conference Series: Earth and Environmental Science, 221(1). https://doi.org/10.1088/1755-1315/221/1/012002
[52] Pugna, A., Negrea, R., & Miclea, S. (2016). Using Six Sigma Methodology to Improve the Assembly Process in an Automotive Company. Procedia - Social and Behavioral Sciences, 221, 308–316. https://doi.org/10.1016/j.sbspro.2016.05.120
[53] R., R., & Mallikarjun, J. (2011). Six Sigma: Improving the Quality of Operation Theatre. Procedia - Social and Behavioral Sciences, 25, 273–280. https://doi.org/10.1016/j.sbspro.2011.10.547
[54] Ferreira, C., Sá, J. C., Ferreira, L. P., Lopes, M. P., Pereira, T., & Silva, F. J. G. (2019). ILeanDMAIC - A methodology for implementing the lean tools. Procedia Manufacturing, 41, 1095–1102. https://doi.org/10.1016/j.promfg.2019.10.038
[55] Rahman, A., Shaju, S. U. C., Sarkar, S. K., Hashem, M. Z., Hasan, S. M. K., Mandal, R., & Islam, U. (2017). A Case Study of Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) Methodology in Garment Sector. Independent Journal of Management & Production, 8(4), 1309. https://doi.org/10.14807/ijmp.v8i4.650
[56] Kumar, S., Phillips, A., & Rupp, J. (2009). Using Six Sigma DMAIC to design a high-quality summer lodge operation. Journal of Retail and Leisure Property, 8(3), 173–191. https://doi.org/10.1057/rlp.2009.8
[57] Nandakumar, N., Saleeshya, P. G., & Harikumar, P. (2020). Bottleneck Identification and Process Improvement by Lean Six Sigma DMAIC Methodology. Materials Today: Proceedings, 24, 1217–1224. https://doi.org/10.1016/j.matpr.2020.04.436
[58] Ericson Öberg, A., Hammersberg, P., & Fundin, A. (2017). Factors influencing control charts usage of operational measures. Measuring Business Excellence, 21(3), 225–238. https://doi.org/10.1108/MBE-08-2016-0041
[59] Osore, E. A. E., Ogola, J. M., & Ogot, M. M. (2020). Prospects of diffusion as a Six-Sigma automation in enhancing continuous improvement of cane juice extraction in Kenya. Cogent Engineering, 7(1). https://doi.org/10.1080/23311916.2020.1733737
[60] Sajjad, M. H., Naeem, K., Zubair, M., Usman Jan, Q. M., Khattak, S. B., Omair, M., & Nawaz, R. (2021). Waste reduction of polypropylene bag manufacturing process using Six Sigma DMAIC approach: A case study. Cogent Engineering, 8(1). https://doi.org/10.1080/23311916.2021.1896419
[61] Sharma, G. V. S. S., & Rao, P. S. (2014). A DMAIC approach for process capability improvement an engine crankshaft manufacturing process. Journal of Industrial Engineering International, 10(2). https://doi.org/10.1007/s40092-014-0065-7
[62] Sharma, G. V. S. S., Rao, P. S., & Babu, B. S. (2018). Process capability improvement through DMAIC for aluminum alloy wheel machining. Journal of Industrial Engineering International, 14(2), 213–226. https://doi.org/10.1007/s40092-017-0220-z
[63] Shokri, A., Waring, T. S., & Nabhani, F. (2016). Investigating the readiness of people in manufacturing SMEs to embark on Lean Six Sigma projects: An empirical study in the German manufacturing sector. International Journal of Operations and Production Management, 36(8), 850–878. https://doi.org/10.1108/IJOPM-11-2014-0530

©IJRASET: All Rights are Reserved

[64] Vendrame Takao, M. R., Woldt, J., & da Silva, I. B. (2017). Six Sigma methodology advantages for small- and medium-sized enterprises: A case study in the plumbing industry in the United States. Advances in Mechanical Engineering, 9(10), 1–10. https://doi.org/10.1177/1687814017733248
[65] Simanová, Ľ. (2015). Specific Proposal of the Application and Implementation Six Sigma in Selected Processes of the Furniture Manufacturing. Procedia Economics and Finance, 34(15), 268–275. https://doi.org/10.1016/s2212-5671(15)01629-9
[66] Smętkowska, M., & Mrugalska, B. (2018). Using Six Sigma DMAIC to Improve the Quality of the Production Process: A Case Study. Procedia - Social and Behavioral Sciences, 238, 590–596. https://doi.org/10.1016/j.sbspro.2018.04.039
[67] Smętkowska, M., & Mrugalska, B. (2018). Using Six Sigma DMAIC to Improve the Quality of the Production Process: A Case Study. Procedia - Social and Behavioral Sciences, 238, 590–596. https://doi.org/10.1016/j.sbspro.2018.04.039
[68] Srinivasan, K., Muthu, S., Devadasan, S. R., & Sugumaran, C. (2014). Enhancing effectiveness of shell and tube heat exchanger through six sigma DMAIC phases. Procedia Engineering, 97, 2064–2071. https://doi.org/10.1016/j.proeng.2014.12.449
[69] Srinivasan, K., Muthu, S., Prasad, N. K., & Satheesh, G. (2014). Reduction of paint line defects in shock absorber through Six Sigma DMAIC phases. Procedia Engineering, 97, 1755–1764. https://doi.org/10.1016/j.proeng.2014.12.327
[70] Sujova, A., Simanova, L., & Marcinekova, K. (2016). Sustainable process performance by application of Six Sigma concepts: The research study of two industrial cases. Sustainability (Switzerland), 8(3). https://doi.org/10.3390/su8030260
[71] Surange, V. G. (2015). Implementation of Six Sigma to Reduce Cost of Quality: A Case Study of Automobile Sector. Journal of Failure Analysis and Prevention, 15(2), 282–294. https://doi.org/10.1007/s11668-015-9927-6
[72] Swarnakar, V., Singh, A. R., & Tiwari, A. K. (2020). Effect of lean six sigma on firm performance: A case of Indian automotive component manufacturing organization. Materials Today: Proceedings, xxxx. https://doi.org/10.1016/j.matpr.2020.07.115
[73] Titmarsh, R., Assad, F., & Harrison, R. (2020). Contributions of lean six sigma to sustainable manufacturing requirements: An industry 4.0 perspective. Procedia CIRP, 90, 589–593. https://doi.org/10.1016/j.procir.2020.02.044
[74] Patel, N., & Shah, S. (2015). A Review on Implementation of Six Sigma in Manufacturing Industries. Journal of Emerging Technologies and Innovative Research (JETIR), 2(2), 368–371. http://www.jetir.org/papers/JETIR1502035.pdf
[75] Tlapa, D., Limon, J., García-Alcaraz, J. L., Baez, Y., & Sánchez, C. (2016). Six Sigma enablers in Mexican manufacturing companies: A proposed model. Industrial Management and Data Systems, 116(5), 926–959. https://doi.org/10.1108/IMDS-06-2015-0265
[76] Tong, J. P. C., Tsung, F., & Yen, B. P. C. (2004). A DMAIC approach to printed circuit board quality improvement. International Journal of Advanced Manufacturing Technology, 23(7–8), 523–531. https://doi.org/10.1007/s00170-003-1721-z
[77] Wang, H. (2008). A review of Six Sigma approach: Methodology, implementation and future research. 2008 International Conference on Wireless Communications, Networking and Mobile Computing, WiCOM 2008, 2–5. https://doi.org/10.1109/WiCom.2008.1887

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)