

Strengthening Six Sigma improvement methodology through Shainin analytical techniques

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Abstract: In the era of globalization any business faces the competition along with lots of emerging opportunities. In order to take advantage of these emerging opportunities and to navigate in the challenging environment, any business whether manufacturing or service are working on the robustness of their process and product. Any variability from the target has a direct bearing on the profitability of the firm. Thus variability reduction is the primary requirement in today's competitive world. It has direct relation with customer mutual value, if products and processes are performing close to the target then very less variation will be present in the final product giving the desired result which can delight the customers. Thus variability reduction is the primary objective of any firm to sustain the globalization and competition. There are many tools, techniques and methodologies present which helps to achieve this primary objective, but Six Sigma or DMAIC (Define-Measure-analyze-Improve-Control) Methodology is one of the strongest approaches for reducing variability form either process or product or both. Good amount of literature is available on Six Sigma theories and applications. Different tools and techniques are being used at each phase of Six Sigma, including Design of Experiment (DOE). One of the DOE techniques is Shainin methodology. Very little literature is available on use of this technique in Six Sigma projects. This paper is an attempt to highlight the diagnostic and analytical efficiency of Shainin methodology which can be effectively utilized at Six Sigma improvement drive. The paper is an outcome of the review of selected scholarly research papers comprising of case studies and review analysis.

Key Words: Six Sigma, Shainin Methodology, DMAIC (Define-Measure-analyze-Improve-Control), DOE (Design of Experiments).

I. INTRODUCTION

Majority of the businesses are facing cut throat competition due to globalization. In today's world all company want to not only satisfy the customers but they are trying to delight the customer (Anupama Prashar, 2016). This goal is achieved through providing the product as per customer need or desire, in technical language product characteristics is as per the specification without any deviation. To achieve this goal all processes are required to deliver close to target performance which leads to very less variation. Six Sigma is one such methodology which focuses on the variation reduction through use of various tools and techniques. Six Sigma is a proven successful methodology which is capable of producing the products which are close to customer requirement. Six Sigma is a set of techniques and tools for process improvement. It seeks to improve the quality of process output by identifying and removing the causes of

defects and minimizing variability in manufacturing and business process.

To enhance the quality by reducing the variability Design of Experiments (DOE) tool like Full Factorial Experiments, Taguchi Method and Sahinin Method are being used . All have their own merits and demerits (A.K.Verma, at el, 2004). Conventional DOE technique and Taguchi methods are comparatively complicated then Shainin Method (Andrew Thomas , Jiju Antony, 2005). Shainin Method contains user friendly tools and logical path which makes the analysis easy and less time consuming (Anand k Bewoor, Maruti S Pawar, 2013). So integration of Six Sigma and Shainin Method can provide effective combination for any process improvement. Shainin Method makes Six Sigma more effective, less complex and less time consuming and easily understandable (Justin T. Aichail, at el, 2014).

Shainin Methodology contains very logical tools which help to carry DOE in most effective manner in less time compared to other two DOE techniques (Jan Kosina, 2015). Taguchi method and Conventional DOE method are very complex and very time consuming, it carries lot of statistical work and analysis which required training of at least 10 to 15 days, even it cannot be understood by the Experienced Worker, sometimes in SME (Small and Medium Enterprises) outside consultants are required to carry out the DOE. Shainin Method removes all difficulties of Taguchi Method and Conventional DOE, it is very easy to understand and very easily applicable, it required training of maximum 2 days and even experienced worker can also apply Shainin method without extensive training (Anupama Prashar, 2014). There are very few research articles which highlighted the effectiveness of Shainin method.

The objective of this paper is to analyze few case studies containing application of Six Sigma and Shainin Methodology separately as well as combined. Further with this study authors intended to highlight the Shainin tools which can be effectively used in Six Sigma project. The main aim of this review paper is to construct the bridge between the Shainin method and Six Sigma methodology which gives most effective methodology for removing chronic problem and for reducing the variability thus any process gives close to target performance.

II. LITERATURE REVIEW

a) About Six Sigma

Six Sigma is process based, Data driven and Customer centric approach for the process improvement (Darshak A. Desai, 2008). The Six Sigma methodology is widely used for reducing the variability of either process or product or both. The birth place of Six Sigma is MOTOROLA Mobile Company USA. During 1980 Motorola was facing higher rejection in their product and suffering from the poor quality process. Motorola was losing their large portion of business due to poor quality issue. A Motorola's Engineer Bill Smith (Father of Six Sigma) came up with concept of Six Sigma Process which was associated with measuring Defective parts per million (DPM) (Kmaran Mosa, Ali Sajid, 2010). According to Six Sigma Methodology standards Failure rate is only two parts per million this was set as the standard for the Motorola. The program to achieve this lofty goal was developed at Motorola and coined "Six Sigma", which included many of systematic and rigorous tools. To define Six Sigma in simple terms is not possible because it encompasses the methodology of problem solving, and focuses on optimization and cultural change. Six Sigma accomplishes this goal by utilizing an extensive set of rigorous tools, uncompromising use of statistical and advanced mathematical tools, and a well-defined methodology that produces significant results quickly.

Six Sigma Methodology is also known as the 3.4 DPMO (defects per million opportunities) i.e. only 3 parts get rejected from the 1 million. A Six Sigma Process is one in which 99.99998027 % of all opportunity to produce some feature of part are statically expected to be free of defects. This tells that 99% of quality level is also not accepted. To illustrate previous statement consider the following facts.

At major airports, 99 per cent quality means two unsafe plane landings per day;

In mail processing 99 per cent quality means 16,000 pieces of lost mail every hour;

In power generation, 99 per cent quality will result in 7 hours of no electricity each month;

In medical surgery, 99 per cent quality means 500 incorrect surgical operations per week;

In water processing, 99 per cent quality means one hour of unsafe drinking water per month;

In credit cards, 99 per cent quality will result in 80 million incorrect transactions in.

(Ref. Mahesh S. Rausinghsani, 2005)

Six Sigma follows the DMAIC methodology for the process improvement and DMADV for the process design it is also known as DFSS (Design for Six Sigma). DMAIC approach carries 5 phases Define-Measure-Analyze-Improve-Control, while DMADV carries same approach till 3rd phase but last two are more on Validation and Design. These two methodologies carry many tools and technique. Which tools used at what phase that's depends upon the nature of the problem and applicability of the tool.

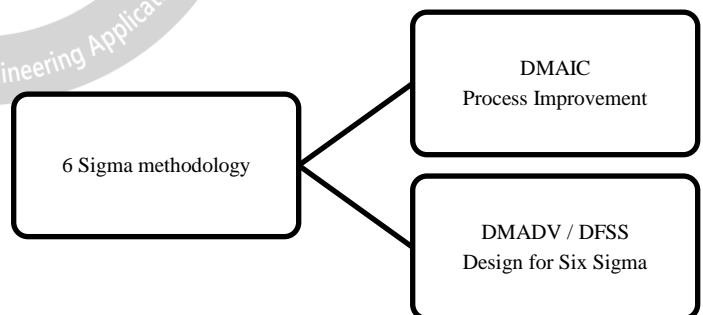


Fig 1. Six Sigma Methodology (Desai, Patel, 2010)

The Six Sigma is a big umbrella (Desai, et al, 2008) which carries lots of tools and techniques under it. Some are 7 QC Tools, 7 New QC tools, Why Why Analysis, QFD, SIPOC, CTQ tree etc and some of techniques are SQC (Statistical Quality Control, Control Charts), Design of Experiments (DoE), Taguchi Method, FMEA, Process FMEA etc. All tools and technique have different application, based on the nature of problem the tool and technique are selected for the process improvement (Desai, et al, 2010).

These tools are divided into three categories: (Ravi S, Snajay D., 2014)

1. Basic Six Sigma : concerned with understanding the problem and solve it through 7 QC Tools.
2. Intermediate Six Sigma : concerned with few enumerative statistical method like Control Charts, Data analysis etc
3. Advance Six Sigma: it include tools like DOE, Taguchi Method, Regression analysis, ANOVA etc.

The basic and intermediate methods are relatively easier to understand and use, the advanced methods are perceived to be difficult to comprehend and interpret. Design of Experiments (DOE) is one such tool which is used during the analysis phase of Six Sigma, It analyzes the relation between the output variable and process variables. A key step in Six Sigma projects is the identification of the root cause of the problem out of the potential process variables. Experimental Design is used to find out the dominant process variable which affects the output variable of the process and leads to variation (Andrew Thomas , Jiju Antony, 2005). There are two well-known approaches for experimental design. The first approach is the classical design of experiments credited to Sir Ronald Fisher who initially experimented in the field of agriculture. However, this method is now widely used in many fields. The second approach is the Taguchi approach pioneered by Dr Genichi Taguchi of Japan who adopted the classical approach to reintroduce the concept of orthogonal arrays. The commonly used classical Design of Experiment (DOE) tools are the family of factorial experiments consisting of full factorial designs and fractional factorial designs. A full factorial allows us to test all possible combinations of factors affecting output in order to identify which ones are more dominant. A fractional factorial tests just a fraction of the possible combinations (Jiju Antony, Alfred Ho Yeng Cheung, 2003). Though a very popular tool, many engineers and quality practitioners find design of experiments difficult primarily because of the complexity

of having to create the conditions for conducting the experiments in an industrial environment where interrupting production lines and changing machine settings may be sometimes difficult and unproductive. An alternative to the Classical and Taguchi experimental design is the lesser known but much simpler Shainin DOE approach.

b) About Shainin Methodology

Shainin DOE approach developed and perfected by Dorian Shainin (Bhote and Bhote, 2000) consultant and advisor to over 750 companies in America and Europe. Shainin's philosophy has been: "Don't let the engineers do the guessing; let the parts do the talking." He introduced the concept of Red X, the dominant source of variation, among the many sources of variation of a problem that inevitably accounts for nearly all the unwanted effect and classified all causes of chronic quality problems into three X's, viz., the Red X, the Pink X- the second most important cause(s), and the Pale Pink X – the third most important cause(s) (Jan Kosina, 2015). According to him, these three Xs together account for over 80 per cent of the variation that is allowed within the specification limit and when captured, reduced, and controlled, these can eliminate this variation (Stefan H. Steiner, R. Jock MacKay, 2014).

Shainin DOE tools and Selection Criteria:

Shainin DOE basically works at eliminating suspected process variables (Xs) mostly by using Eight different tools as follows (Sunil Sharma, Anuradha Chetliya, 2009).

- Multi-Vari Analysis
- Component Search
- Isoplot
- Paired Comparison
- Variable Search
- Full Factorials
- B vs. C (Better vs. Current) Analysis
- Scatter Plots or Realistic Tolerance Parallelogram Plots

Table 1 : Shainin Tools (Sunil Sharma, Anuradha Chetliya, 2009)

Tool	Objective	Where Applicable	When Applicable	Sample Size
Mulati Vari Chart	To reduce the large no. of unrelated variable to small no.	To get a snap shot how Process is running	During Production or Pilot Run	Min 9-15
Component Search	To find out the RED X if it is in process	In assembly process	During Production or Pilot Run	2
Isoplot	To check the Measurement System is correct or not	At any measurable test bench	Initial stage to conform the source of variation either due to measurement system or process	30
Paired Comparison	Provide clues to determine the RED X through Bad part Good Part comparison	When Product cannot disassembled	During Production or Pilot Run	1 to 20
Variable Search	Pin point RED X, PINK X and find	When no. of variables	In R & D, Production, Development	1 to 20

	out the impact of variables and its relationship	are between 5 to 20		
Full Factorial	Same as viable search	When no. of variables are between 2 to 4	Same as viable search	1 to 16
B vs C	To compare the Current process with proposed process	Usually follow any one of above tools	In production or pilot run	3 B and 3 C
Scatter plot	Determine the optimum value for RED X, PINK X and their maximum tolerance range	Follow above tools	In pilot run	30

Shainin projects feature the discovery of critical relationships through rigorous detective work. Shainin talks to the parts and discovers the Red X by taking advantage of performance differences between the best and worst parts. Rather than ask subject matter experts to list possible causes, Shainin uses their insights to develop a strategy to force the parts to reveal their differences. The Shainin problem solving roadmap is FACTUAL™ (Focus, Approach, Converge, Test, Understand, Apply, Leverage) (Jan Kosina, 2015).

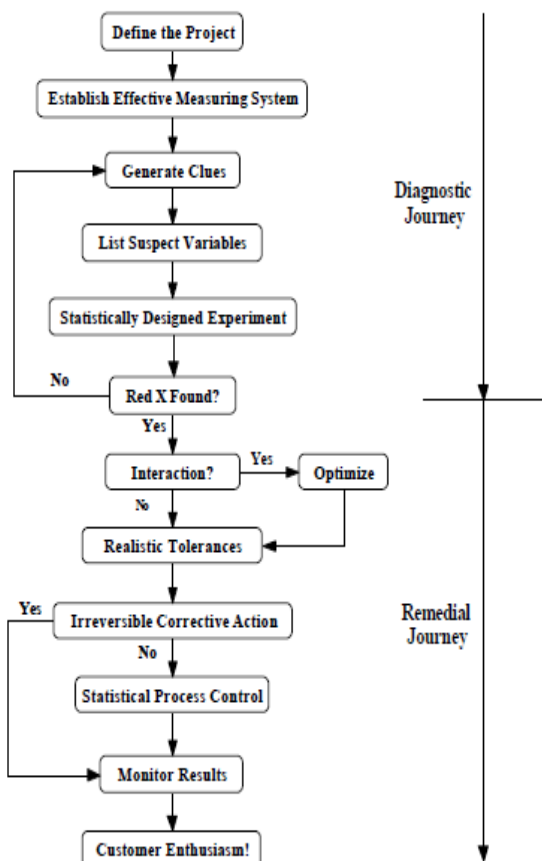
F	A	C	T	U	A	L
FOCUS	APPROACH	CONVERGE	TEST	UNDERSTAND	APPLY	LEVERAGE
<ul style="list-style-type: none"> Multiple Metrics Leveraged and Project Impacted Project Definition Staffing Matrix Complete 	<ul style="list-style-type: none"> Green Y Description Strategy Selected and Best Contrast(s) Leveraged Measurement System Verified 	<ul style="list-style-type: none"> Converging on the Red X Red X Candidate Identified 	<ul style="list-style-type: none"> Risk Assessed and Type of Confirmation Experiment Applied Red X Confirmed 	<ul style="list-style-type: none"> Green Y to Red X Relationship Understood and if Appropriate Tolerance Limits Established 	<ul style="list-style-type: none"> Corrective Action Implemented and Verified Corrective Action Proceduralized Project Duration Project Benefits and Cost Savings 	<ul style="list-style-type: none"> Read Across Implemented and Additional Savings Calculated Lessons Learned

Fig 2. Shainin FACTUAL Approach (Ref. Jan Kosina, 2015)

Fig 3. Road map of Shainin Methodology

III. METHODOLOGY

The main aim of this study was to systematically review good research paper form the reputed journals which are directly related to the Shainin Methodology, Six Sigma Methodology, Quality Improvement, Shainin Six Sigma combine work. To fulfil the aim total 50 papers have been rigorously reviewed from reputed national and international journal as shown in the Fig 3. Appendix 1 indicates the summary of articles reviewed. For more reinforcement review paper and pure application based paper was reviewed, the review paper strengthening the theoretical part and clear the fundamental about Shainin method, Six Sigma Shianin method, Way of carry out work etc, while application base paper provides the actual real time scenario about the topic, which gives the information about the hurdles during implementation and way to overcome it with good result. Fig 4. shows the type of paper. Fig 5. Shows the topic wise distribution, all 50 papers are not on the single topic some of them are on pure Six Sigma, some them are on Shianin method, some of them are on both Shainin as well as Six Sigma etc, This approach is provide strong platform to correlate Shainin and Six Sigma methodologies.



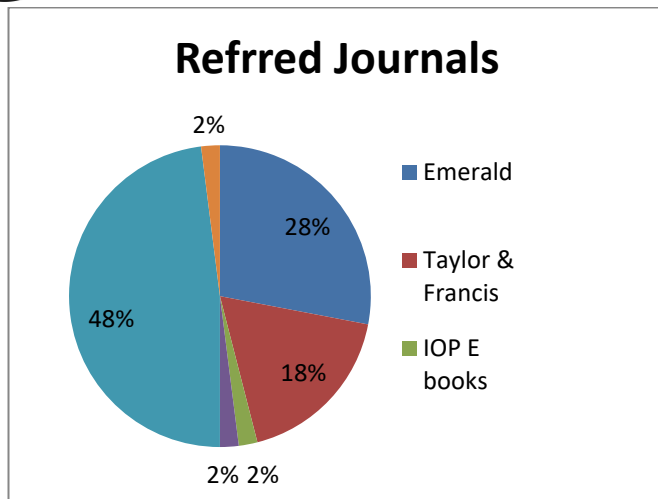


Fig 3. Referred Journals

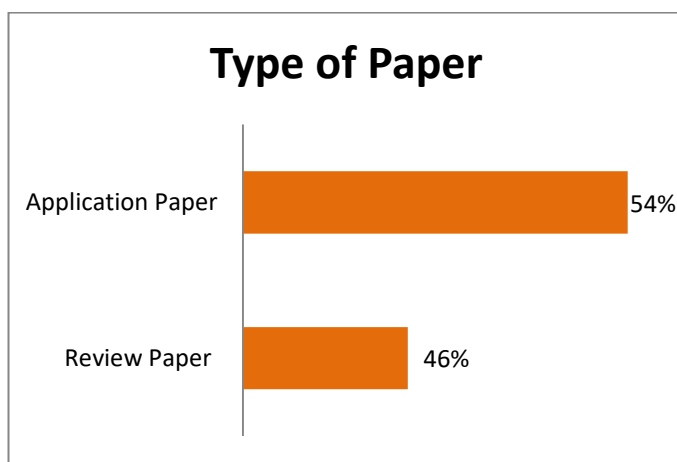


Fig. 4 Type of paper

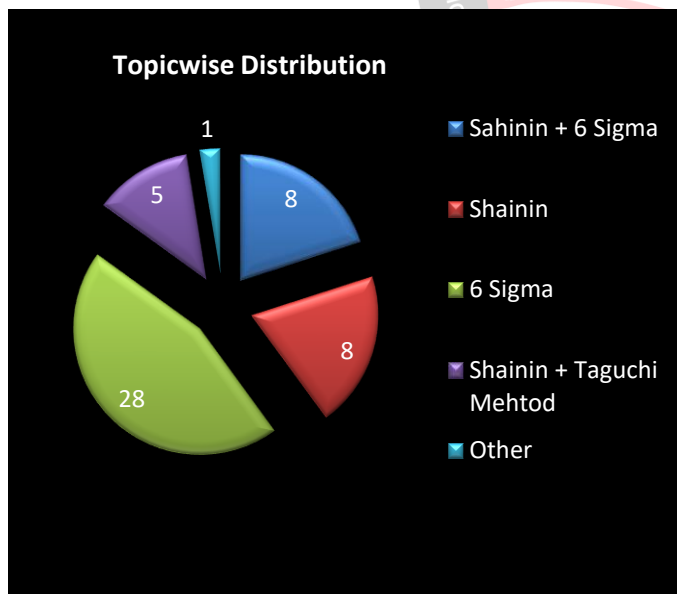


Fig. 4 Topic wise distribution

For making more stronger review there are some books also being refereed based on Shainin method, Six Sigma Methodology, Tools and Techniques of Six Sigma , DMAIC Methodology, Shainin tools etc, it clears the basic fundamentals. There are few case study also review which

are open on the internet but not publish in any journal in the form of paper.

After scanning a large bulk of articles and books, to stay focused and not to diverge from the research aim, 50 articles which are suitable to the context and flow of the discussion are selected during the construction of the study. Each article was carefully reviewed and the paper was organized to reflect the status of perception of tools and techniques in the literature. This research serves as a comprehensive base for a complete understanding of what are the Shainin tools being use during Six Sigma Project and how they make Six Sigma more effective.

IV. ANALYSIS AND DISCUSSIONS

Six Sigma is the methodology focus on reducing variation from the process and gives close to target performance, Most of Six Sigma projects are based on the heavy statistics which include the regression analysis, designed experiments, hypothesis tests, analysis of variance (ANOVA) and control charts (Bhaskara P, at el, 2014). Fishbone diagram and brainstorming are the analytical tools mostly used during analysis phase to find out possible root causes. Project success depends on the true root cause being on the list. This is divergent approach thus statistical analysis is used to calculated results from the assessment of large data sets (John Goodman, David C. Wyld, 2001).

The underlining principle of statistical problem solving is $Y = f(x)$. This drives teams to identify all factors that can possibly influence the value of the key output (Y). The expansion of this equation is $Y = a + bx_1 + cx_2 + dx_3 + \dots + mx_n$. A successful project will find all coefficients (a, b, c, d, etc.) that are statistically significant. The DMAIC (Define, Measure, Analyze, Improve, and Control) process supports this approach (Detroit, at el).

The main difficulty faces during the Six Sigma project is statstical analysis. It required extensive training of at least 7 to 10 days. Shainin method is one of the method if its use during the analysis phase of Six Sigma then defiantly it convert the Six Sigma in more effective manner compare to conventional Six Sigma. Shainin projects are evidence based; converging on the largest source of variation, the Red X. For a Shainin project, the underlining principle is $DY = f(Dx)$. The expansion of this equation is $DY = a + bDx_1 + cDx_2 + dDx_3 + \dots + mDx_n$. By focusing on variation, i.e., the change in Y, the goal becomes the discovery of the term with the largest value. The largest value will result from a combination of a significant coefficient and a large change in X. This term is seldom the term with the largest coefficient. The Pareto principle requires a substantial difference in the contribution in these terms to the change in Y. The goal of a Shainin investigation is to rapidly converge on the critical few terms contributing most of the variation. In many projects, the Red X is an interaction among independent inputs (Xs).

Shainin tools are highly effective in revealing these interactions (www.shainin.com).

But there are some difference in Shainin method and Six Sigma methodology (www.shainin.com).

1. The approach step is one of the key difference between Shainin and Six Sigma methodology, during approach stage Shainin more emphasis on the checking the Best of Best (BOB) and Worst of Worst (WOW) parts and based on that natural of problem and key cause RED X identified. It is convergent approach although Shainin method also required Statistical analysis background for the graphical analysis.

While Six Sigma is divergent approach, from many causes key cause identified by multi voting, rigorous Statistical analysis etc. It becomes more complex and time consuming compare to Shainin Method.

2. In shainin method after finding the RED X the validation of it must be done. It is refer that taking the RED X to court. This is detective type of work protects company from investing in solution for the wrong root cause. Part itself tells about the Problem "Talk to the part" rather generating possible clauses. It gives the exact reason of the problem.
3. Six Sigma is more stronger in the Control phase compare to Shainin Method, Six Sigma includes variety of the control chart (\bar{X} bar , R , C, P ,nP Chart etc.) all have different applicability as per situation. While in Shainin method have only one tool scatter plot is used in control phase which is not effective as Six Sigma. Remedial phase of Six Sigma is more powerful compare to Shainin method, but Diagnostic phase of Shainin method is more effective and powerful compare to Six Sigma.

V. CONCLUDING REMARKS

After critically review 50 papers, Books & Open case studies following important points are extracted.

1. Six Sigma is process based, customer centric and data driven approach, which gives breakthrough improvement in any business process.
2. It focuses on the chronic problem and eliminate it and reduce the variability present in the process and gives close to target performance.
3. Six Sigma is an umbrella which carries many tools and techniques as well as statistical analysis which are applied appropriately in each phase of DMAIC.
4. Design of Experiments (DoE) is one of the widely use techniques for root cause analysis. Three different DoE methodologies are in existence

mainly, Classical, Taguchi Method, Shainin Method.

5. Among the 3 DoE methodologies Shainin method is comparatively easy to understand and implement even by lower experienced worker.
6. One of the misconception on Six Sigma, especially by SME it requires considerable statistical analysis and engagement of outside consultant for successful execution of the project. – by application of Shainin methodology this misconception can be removed to a considerable extent.
7. The powerful diagnostic and analytical techniques of Shainin methodology can be effectively used in Six Sigma improvement project. However very few case studies reported for the same.

This study has revealed the weaker and stronger part of Six Sigma improvement methodology and Shainin DoE technique in comparison to each other. Both are having improvement potential if used separately, but requires more resources and effort to achieve the targeted improvement, where as merger of the two can prove to be more effective and efficient drive. This review analysis will be useful to industry as well as academia to effectively utilise Shainin tools appropriately at Six Sigma improvement projects. It is expected that more case studies using combination of Six Sigma and Shainin methodology at different size and sector of the industries be reported in future.

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Appendix 1 Summary of articles reviewed

No	Authors	Type of Paper	Core theme	Application Area
1	Ronak Gupta, at el, 2016	Review paper	Comparison between Tools and Techniques used in Six Sigma & Shainin System	SME
2	Jan Kosina, 2015	Review paper	provide a brief overview of Six Sigma and Shainin RED X methodology and to propose the modification of the Six Sigma methodology in order to achieve better efficiency in the diagnostic journey of the DMAIC phases of Six Sigma	Automotive Supplier, Small Scale Industries which are lacking in the Statistical Knowledge such as small scale Foundry, jobbing Foundry, Jobbing Machine shop
3	Jo Mooren, 2016	Application based paper	Case study gives the background of the Shainin System bases problem solving technique	Case study done on the PHILLIPS Fridges
4	Stefan H. Steiner R. Jock MacKay, 2014	Review paper	Information about the methodology and phases of the SS that is FACTUAL approach.	Medium to High volume production
5	Bhaskara P, at el, 2014	Application based paper	This paper is based on real problem occur in the BOSCH industry. Diesel system equipments has successfully employing the efficient statistical tools SHAININ for the root cause identification and DOE for analysis and optimization of quality related issues	BOSCH Ltd. Bengaluru, MNC
6	Justin T. Aichail, at el, 2017	Application based paper	Compare the all 3 DOE technique with its merits and demerits	SME
7	Pooja Margi Dr. H. Ramkrishna	Application based paper	Six Sigma and Shainin combine approach to reduce the rejection in Automobile Industry	Ashok Leyland
8	Andrzej Pancana Jarostaw Sep Dorota Stndnicka, 2010	Application based paper	optimizing process parameters through shainin DoE	Burnishing process
9	Abhaysinh Desai , L.M.Jugulkar , 2014	Application based paper	Reducing variability of process using DMAIC and Shainin combine approach	Engine manufacturing firm
10	Sunil Sharma Anuradha Chetliya, 2009	Application based paper	Compare the all 3 DOE technique with its merits and demerits	In analysis phase of Six Sigma
11	R. B. HEDDURE M. T. TELSANG, 2014	Application based paper	reducing rejection through shainin method	Medium Scale Foundry unit
12	Anupama Prashar, 2016	Application based paper	reducing rejection through shainin and Six Sigma Combination	Automobile Industry

13	Anand k Bewoor Maruti S Pawar,2013	Application based paper	objective of the paper is to examine the usefulness of the Shianin methodology for simplifying implementing Six Sigma in Indian SME	Small scale Welding unit
14	Rahendra Khavekar , Dr. Hari Vasudevan, 2010	Review paper	Enhancing the Quality through deployment of DOE in the Analysis phase of Six Sigma journey. DOE like Taguchi Method, Shainin System helps to optimize the process or product which leads to improve the quality and gain competitiveness in the global market.	review paper which compare and explore the concept, definition and significance all DoE methods
15	A.K.Verma, al et, 2004	Review paper	Compare the all 3 DOE technique with its merits and demerits base on common problem	review paper which compare and explore the concept, definition and significance all DoE methods
16	Andrew Thomas Jiju Antony, 2004	Application based paper	This paper illustrate Shaiin Variable search methodology which helps to find out RED X, PINK X from multiple variable	Manual adhesive process in Aerospace industry
17	David M Plum, Heather Fyot , Joel Jacobson, 2015	Review paper	Review paper based on the application of Multivari Chart	To find out variation w.r.t time , Operator, piece
18	Anupama Prashar, 2016	Application based paper	This Paper focus on the Six Sigma Methodology for the Quality improvement with use of the Taguchi Method and Shainin method for more effective implementation of Six Sigma with less effort as compare to conventional Six Sigma Method.	Automotive supplier which faces the rejection in the shock absorber
19	Jiju Antony, 1999	Application based paper	Paper focus on one of the tool of Shianin that is Variable Search Analysis.	VSA apply on the simple paper helicopter to set optimum length wings
20	John Goodman David C. Wyld, 2001	Application based paper	This article documents a case study in the use of Shainin DOE (Design of Experiments), carried out in an industrial honing operation.	The objective of this paper is to show that a valid, reliable, user-friendly al tentative to conventional statistics exists to assist any manufacturer interested in using simple DOE to gain greater control over its manufacturing processes.
21	Jiju Antony, Alfred Ho Yeng Cheung, 2003	Application based paper	Paper focus on one of the tool of Shianin that is Variable Search Analysis.	to find and optimize the parameter which gives the maximum distance cover in flight.
22	Andrew Thomas , Jiju Antony, 2005	Application based paper	The main purpose of this paper is to highlight the application and to compare the effectiveness of the Taguchi and Shainin experimental design processes as applied to aero space component.	This Paper focus on the improving the joint strength of Honey Comb Aero Space structure.
23	Mahesh S. Rausinghani, 2005	Review paper	The main purpose of this paper is to provide a sound discussion on the Six Sigma methodology and compare with other quality improvement initiatives.	This paper fulfills an identified information need for the Six Sigma methodology
24	Dr. RajeshKumar U Sambhe, 2017	Application based paper	Six Sigma Methodology is executed on the one of the product assembly for trimming down the rejection level	Medium sized Auto ancillary
25	Ravichandran Joghee, 2017	Application based paper	Six Sigma quality control chart (SSQC) for the benefit of Six Sigma Concept which leads to reduction in the variation in process or product	Main aim is to set the SQC control chart limits in Six Sigma Quality level.
26	Sunil Sharma, Anuradha Chetliya, 2012	Review paper	The purpose this paper is to explore and analysis Six Sigma Critical Success Factors (CSF) in the context of Indian manufacturing company.	In all segment of businesses
27	Meryem Uluskan, 2016	Review paper	comprehensive literature research, the most used tools, classification of tools, flow of tools with respect to different flow of Define, Measure, Analysis, Improve and	In all Six Sigma Project

			Control steps	
28	G.V.S.S.Sharma, P.Srinivasa Rao, 2014	Application based paper	This paper focus on the process capability index Cp improved from 1.29 to 2.02 and Process performance index Cpk from 0.32 to 1.45.	Crank manufacturing process in Automobile Industry
29	Jyoti Prakash Majumdar, B. Murli Manohar, 2011	Review paper	highlight the probable reason for the failure of the Quality Circle in the Indian Manufacturing Industry	In all level of industries
30	T N Goh, 2010	Review paper	This paper talks about the What are the Constituents of the Triumph with respect to Six Sigma.	Provides road map for Six Sigma implementation in all level of firms
31	Erick C Jones, Mahour parasat, Stephani Admas , 2010	Review paper	This paper introduce the frame work for implementing Six Sigma project by PDCA (Plan-Do-Check-Act) cycle	Integration of Six Sigma DMAIC phases with PDCA steps, developing the framework which integrate the both methodology for the successful implementation and final stage is to measure the performance and control it.
32	Doug sanders, Cherale Hild, 2008	Review paper	Paper gives the information about the success story of Six Sigma implementation and also provide the information about misconception develop during the implementation of the Six Sigma project.	This Provide systematic detail information about the myth of six sigma projects, it also gives the information about the some prevention or caution which mislead the project.
33	Joghee Ravichandran, 2017	Application based paper	Six Sigma quality control chart (SSQC) for the benefit of Six Sigma Concept which leads to reduction in the variation in process or product	Main aim is to set the SQC control chart limits in Six Sigma Quality level.
34	Rmakrushna Padhy, 2017	Review paper	The Paper aims to review the literature on the six sigma project through broad frame work of the Six Sigma Project selection.	To identified various tools and method associated with project selection
35	Kmaran Mosa, Ali Sajid, 2010	Review paper	This paper introduce about learning of Six Sigma process, i.e. how to conduct the Six Sigma Project, What are the implementation criteria, training, How to apply Six Sigma, What is the actual meaning of Six Sigma, Different phase of the Six Sigma.etc.	In all Six Sigma Project
36	B.Tajhono, at el, 2010	Review paper	The purpose of work is to capture the current state of Six Sigma as well as to document the current practices of Six Sigma through a systematic literature Review.	In all level of industries
37	Dana Krueger, Mahour Parast, Stephanie adms, 2014	Review paper	This approach of study provide in depth understanding of six sigma implementation at local level and it also provide a systematic path to new project.	In all level of industries
38	Ravi S, Snajay D., 2014	Review paper	The main aim of this paper is to explore field of Six Sigma and discovers the limitation of the reviewed limitation of present studies.	In all level of industries
39	N. Vekatesh C. Sumangala, 2018	Review paper	This paper makes an attempt to examine few companies that have implemented Six Sigma.	In all level of industries
40	Jiju Antony, E V jijo, S J Childe, 2012	Application based paper	This article discusses the successful implementation of Six Sigma methodology in a high precision and critical process in the manufacture of automotive products.	automotive Industries

41	Darshak A. Desai , 2007	Application based paper	This paper illustrates the efforts to introduce and implement COQ at SME and is a real life case analysis. The quality costing approach is adopted containing four basic elements: prevention, appraisal, internal failure and external failure.	SME and MSME
42	Darshak A. Desai , M B Patel , 2010	Review paper	This paper focuses on Six Sigma implementation in Indian industries and also gives the information about the Success story and hurdles in implementation.	In all level of industries
43	Darshak A. Desai , M B Patel , Jiju antony 2010	Review paper	This paper is to present the results from an empirical investigation of Six Sigma status in Indian industry, especially to highlight critical success factors (CSFs) of Six Sigma implementation in a developing economy like India.	In all level of industries
44	Darshak A. Desai , Aurangzeb Javed , 2017	Application based paper	This paper, a case study, aims to illustrate the application of Six Sigma in a small-scale ceramic manufacturing industry. The rejection percentage has been reduced from 0.5 to 0.1 percent and consequently the Sigma level has been improved from 4.4 to 5.0.	High voltage (HV) testing of one of the most critical products, insulator.
45	Darshak A. Desai , 2012	Application based paper	This paper illustrates a real life case study of practicing Six Sigma at a small-scale foundry industry.	Small scale Foundry
46	Darshak A. Desai , 2008	Application based paper	This paper illustrates a real life case study of practicing Six Sigma at small-scale jobbing engineering concern	Small scale Jobbing Industry
47	Darshak A. Desai , Tejaskumar Parasana 2012	Application based paper	This paper deliberates the quality and productivity improvement in a cylinder head manufacturing enterprise through a case study and deals with an application of Six Sigma methodology.	Cylinder manufacturing firm
48	Nayankumar Prajapati, Darshak Desai, 2012	Application based paper	This paper is an attempt to highlight the benefits that can be reaped by EOUs. Along with the end effect, the paper also shows the level of customer requirement and competition faced at the global level by such a EOUs.	Export oriented units (EOU)
49	Jigar Doshi, Darshak Desai, 2016	Application based paper	The case study-based research was carried out in four automotive SMEs; all of them are suppliers to automobile OEMs. SPC is one of the important automotive core tools to examine and monitor a process variation and that provides the means to improve process continuously based on numerical results.	Automobile ancillaries
50	Darshak A. Desai , 2006	Review paper	The paper discusses the real life case where Six Sigma has been successfully applied at one of the Indian small-scale units to improve one of the core processes.	Small Scale Industry of item