A Review Paper on Simulation Based Six Sigma Approach in Quality Assurance

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Abstract—The main purpose of this research is to use "DMAIC" and "DMADV" framework of six sigma to reduce cost of projects, increase yields, improve performance and reduce defects. This study conclude that the sigma level of cement bag production in four production lines is "4.7 DPMO" values of 710 and the possibility of defects per unit of 11 possibilities this situation was handled by using six sigma. Any business or industry run only to satisfy customer and increase their profits, this can be attained as development of quality product..For the ranking of newly established universities the certification of those institutes is very important and also a critical process. For this process we used Lean six sigma approach that can identify the wastes that affect this process.Six sigma can be applied to any work field such as education, power optimization and other types of industries Six sigma "DMAIC" approach is also used for the testing of EDA tools that occurs due to the complex coding or configurations, flows and platforms they support. To improve the process quality of SDLC it's necessary to remove the defects of system in advance along with thorough valuation of size and it also makes project accordant with real time environment

Index Terms—six sigma, lean six sigma, DMAIC, DMADV, agile, defect per million opportunities(DPMO), SPC.

I. Introduction

Software industries got increasing nowadays. As different software industries need different theoretical analysis for the manufacturing of software and implement them in different organizations. Manufacturing of these software need repetition of execution of tasks; tasks can be design and evaluation that are usually done on early stages. So the chance of defects in any software increases. Our aim is to produce error free products that fulfill customer requirements and satisfy them. In order to fulfill all these factors Motorola introduces six sigma processes. Six sigma is a broad, adjustable process to identify and remove defects and increase the yield of products. Six Sigma is uniquely derived by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes.

To gain the six sigma it is necessary that product not produce "3.4 defects per million opportunities". "DMAIC and DMADV" are the two frameworks of six sigma. Each has its own function and usage in different situations. The six sigma in software industry requires a lot of critical analysis to check it is beneficial for software or not and how it can be improved. In this paper we analyse different case studies to determine the implementation and usage of six sigma in different fields such as cement industry, sanitary ware production, health care logistics, bank customer satisfaction, designing a test fixture etc.

In this paper we discuss the concept of design of six sigma and lean six sigma tools for design of hydraulic line test fixture which is used for marine risers. In the solution of this problem we explain DMADV framework. Lean six sigma is a combination of both lean and six sigma processes, some business used the combined features to produce the high quality product with good services, low the cost and increase the reliability. Quality and cost reductions are one of the important activities to be addressed in six sigma approach. "TQM", Lean Manufacturing, and Six Sigma are basically implemented as operational measures to cope with the change in comparative environment.

Six Sigma methodologies is one of wide-ranging and supple structure to attaining, defining and increasing success of a business. Data analysis, Statistics analysis, Customer

requirements and expectations and result improvement are main aims of using six sigma methodologies. Coordination of customer, information and facts, process and improvement focusing and practical controlling [9]. Six sigma is efficient method and Project driven approach. It concentrate on client requirement, profit, yield, business system and minimum cost. It increases performance of industries such as construction, engineering and banking [15].

In power distribution which is a common business practice, process improvement is done any by reducing number of interruptions and time, less number of resource consumption to improve process performance. And this can be achieved by six sigma methodology [10]. Design for Six sigma is also applied to education system development process as quality is important factor for any industry especially in education systems and can be attained through this methodology. DMAIC methodology is used to increase the performance criteria. [18]. Process variations and improvements are done for the data analysis and statistical techniques, six sigma works on the quality performance and evaluate the zero defects ability of procedure [16].

As the discharge process creates problems in nature so simulation provides exciting platform that capture the complex features and also predict significances of potential improvement efforts. For this purpose (discrete event simulation) DES approach that combined with six sigma DMAIC frameworks is used that focuses on managing bed ability, enhanced patient flow, scheduling the staff, and handling patient scheduling processes [7]. For the testing of EDA tools our main focus is to reduce the weightage of defects before the product launching through this we can save money and also its better to remove the defects before the product launching rather than after launching of product [8] . 3D FP is applied on the testing phase that helps to check from where errors occurrence is above the output value [11]. "NCAAA" and "ABET" are the agencies that provides certification to institutions on the basis of evidence that support and evaluate quality assurance processes and the program meet the needs of students or not

[14].

The important highlights of paper are:

Section II describes the literature review. Section III describes the full analysis of papers that we studied in our research. Section IV describes the conclusion that we conclude by our research.

II. Literature Review

Six sigma is actually a set of tools and techniques for the improvement of processes developed by "Motorola" in the mid of 1980's. This technique helps to increase the product performance and decrease the variations that lead the defects in the products. Six sigma consists of basic six factors: "define

measure, analyse, improve and control". There are different ways to define the concept six sigma but its developer Motorola define it as a quality improvement program with a special aim to reduce the number of errors as much as possible. This strategy is not only use in software industry but all other fields as well like health care centres, banks, sanitary ware production centres, cement industries etc. that we will discuss later in our research. Six sigma has two major structural methods: "DMAIC and DMADV". "DMAIC" is used for process refinement and "DMADV" is used for process and product designs. Six sigma has three levels: metric, methodology and philosophy. In healthcare logistics six sigma plays its role by identifying and remove the expired products and medicines. As we all know that logistics systems for health are very complicated because products are classified into groups based on patients care. The important factor that make logistic complex is the criticality of items that are used for patient's life threatening situations but six sigma by its important factors solve this problem and support the problems related to hospital logistics [3].

Similarly to warpage of defects related to sanitary ware production "Tossapol" and "Rachan" discuss and used DMAC methodology in which they describe customer deliverable goals for which they discuss "Preto" chart and fish bone diagram. Then all factors of six sigma mapped on problem to measure the critical factors, analyse the root causes, improve the situations and apply the changes [5].

In bank for the satisfaction of customers "Zhiyi Zhuo" applies six sigma quality steps to control future defects by applying measure according to customer needs [6]. A "DFSS" for test fixture is also discussed along with lean six sigma. "Lean six sigma" is basically a DFSS, DMADV and DFSS are almost same concepts. For further up gradation and new concept lean was introduces define as "not to minimize the cost, values and time but maximize all these values" and now this is most demanding concept for customers to reduce waste activities. DFSS tools include project charter, tree diagram, Gantt chart, SPIOC diagram and WBS [2].

In 2016, the enhancement quality of plastic company is studied and that involve the six sigma approach. The purpose of using this approach is to estimate the quality of molding inking in company producing plastic self-propelled goods. It strictly follows six sigma phases [9].In define phase the main processes and customer satisfaction criteria are well defined, in measure phase data is collected through determinate constraints all the critical constraint that will effect quality and reflect on result are identified, analyse phase involves data analysation that will help to calculate working variances. In control phase the work done is secured from the risk factor and effecting methodologies [15].

The survival of any industry depends on quality. For the educational system customers are parents and society, Suppliers are intermediate students, the input will be

Students, Faculty Laboratory, Lab technicians Equipment Lab technicians, the processes applied on the students are Teaching, Learning, Guiding, Counseling, Evaluation and the output of all these effort are Graduate Engineers. Educational system's performance can be enhanced by DMAIC methodology of six sigma approach. To achieve the high quality performance sigma is calculated, regression and clusters are analysed, and correlation and square summary and baseline statistics is developed [18].

Six sigma works together with data analytics to produce high quality with minimum number of defects in plants. Using Control phase of six sigma data is collected, data is mapped and irregularity is exposed remedial schedules for the failures are drawn [16]. Reduction of the disturbance in Distribution of power also involves DMAIC. During phase of DMAIC Project charter, process map, benchmark is the tools data collection, sampling, sigma calculation, Design optimization, brain storming, robustness, Error proofing, standards are build. This technique deals with nourishing the upgraded level of functioning of the power distribution process [10]. This methodology is also used for Robust Optimization. Worst case is adjusted and number of defects is reduced to zero to sustain the optimality of the system [17].

In software industry to obtain the good quality product Six Sigma and 3D function point's approach is used widely. Its purpose is to generate products which have zero defects. To reduce the errors some changes are made to verify that it fulfills the customer requirements or not [11]. To improve the discharge process of patients in the hospitals the six sigma "DMAIC" approach is very useful. The reasons of this problem include the disjointed and non-standardized measures and absence of conversation between the stakeholders. Many hospitals met the problem of overcapacity in emergency departments. Due to this delay in diagnosis, treatments and poor quality of care is occurred.

Six sigma quality management approaches is used to reduce the distinction, evaluating defects and to improve the quality of products, processes, and facilities [7]. Due to the increasing complexity of electronic designs the "EDA" tools turn into more refined and able to face unbelievable tasks to conduct with developing technology. The testing of "EDA" tools is one of the main tasks during its development phase before the launching of product. The testing is about to verify that the tools work correctly or not and to check its performance with less time intake and less usage of memory .For the testing of "EDA" tools the six sigma "DMAIC" approach is used that solved the root cause of the problem with "EDA" tools and logically grasp the solutions[8].

To enhance the quality of processes in food industry the "SPC" (statistical process control) as six sigma technique is used for process control and to conclude that the tools are suitable at each step of execution or not . These approaches focus on the importance of statistical techniques in the decision making process for the management of operations in organizations [12]. The evaluation of critical factors on the quality of process and to check which factors are the main cause of failure is very important in the field of diagnostic and power electrical engineering. By applying Lean Six Sigma technique and Fuzzy approach on process levels this problem is reduced [13]. Around the world it's a goal for all the countries to improve the education. For the authorization process the documentation of educational and governmental actions is required, which involves careful management, planning for well-timed collection and investigation. For this purpose the Lean Six Sigma approach is used that can improve the performance by removing waste that appear in education programs [14].

III. METHODOLOGY

The word sigma means variation in data so six sigma means that six standard deviation or a set of techniques to reduce defects, bugs and improve performance. In software industry it is very important to achieve aim without any defect. By the end of 1970 Japanese industry beat many opponents using technology, Motorola was one of them then Motorola decided to develop a six sigma techniques and he succeeded to implement it. This six sigma approach was also implemented in general "electric and Texas instruments". Two frameworks of six sigma were developed each with own purpose. "DMAIC" is used when process exit but do not meet the client's needs and "DMADV" use when a new process has to develop or "DMAIC" fails to perform work.

As software industry is human centric because software construction is a process of building software by collecting, analysing and implementing the requirements, all these activities are human dependent so, it is necessary that human have good skill of creativity, innovation etc. If all these skills are not present in human then software that they develop is full of errors and we have to use six sigma approach to find the root causes of bugs and solve the problems. In software industry agile, six sigma and lean are used during development and reduce waste activities but there is a small difference among them. Table I shows the comparison:

AGILE	SIX SIGMA	LEAN SIX SIGMA
It focuses on effective changes and their management that comes from customer after some breaks but it continuously deliver working product.	"Six sigma" is a technique/ methodology to improve performance and reduce defects rate. It monitors defects and variations as waste activities.	Lean was developed by Toyota. It eliminates the waste activities, put effort for execution of projects and add value to final products.

TABLE I

COMPARISON BETWEEN AGILE, SIX SIGMA AND LEAN

In sanitary ware production we can reduce losses by using six sigma frameworks "DMAIC". Warpage is a transformation of shape and dimensions due to which products look poor. In our research we study the toilet bowl AC19 model with 17 percent of total defects. By using six sigma authors find out the root causes of defects and improve the product yield. For the solution of this problem Toppasol and Rachan used "Shainin DOE" technique with most important factor to identify variables in developing procedure. The variables are "RedX, PinkX, PalePinkX". This techniques work by identifying input factors by marking WOW and BOB levels. Then separate important and unimportant factors and finally analyse the factors.

For the improvement of model AC19 first define phase was done to identify problem in product. Problem found in shape and dimensions, then measure phase was done to find the location of problem different location were mapped but location 11(black part next to the wall was more defective with 88 percent defective rate. Then analysis was done on it by applying "Shainin DOE" on the bases of "flatness of base clay and flatness of clay batt" the results that were obtained as:

Customer satisfaction and reliability of the system is directly

PARAMETERS	LEVELS	
	LOW LEVEL (wow)	HIGH LEVEL (bob)
Flatness of base clay	0 mm	2 mm
Flatness of clay batt	1.5 mm	0 mm

Fig. 1. Results obtained from "Shainin DOE experiment"

cluster analysis in education systems. In cluster analysis we classify substances, items or cases into groups or clusters. Former information about groups or clusters is not provided. Four categories are built on the basis of semester marks and then we calculate summary of cluster center, mean value, average marks for each of clusters. This shows rank of each cluster. The relationship between different variables of unique entities of data can be calculated by measure of average called Regression analysis. System input and outputs from experiments are measured to create an equation or transfer function.

Sensitivity analysis, system performance optimization and system tolerance is calculated by transfer function obtained through regression. Quality of robustness can be improved connected to service quality. Six sigma applies regression and by SSQ method. It is an efficient method to reduce computational time. It provides trustworthy calculation of average performance. Six sigma standard deviation levels are

used to measure the dispersion. It can be formulated as; min μf and f . Intensity of variation can be indicated by f which the standard deviation and average performance within the uncertain range can be defined by the mean value μf. Higher the standard deviation value the better will be the robustness. Objective function is used in Kriging model in which objective function is predicted and SSQ method or gradient difference method is used to measure the sensitivity. On the basis of the sensitivity the robustness of result is then marked as high or low.

The improvement was applied on the product by deciding to redesign clay and new design was introduced after that which was rubber free. Then it was control and checked how and what problem is now again occur but at that time problems were reduced and defect rate was 5.58 percent with 10 percent increase yield rate . The next case study that we study in our research is DFSS for test fixture. DFSS is basically composed of "DMADV". The main objective of text fixture that we study was to reduce assemble and dissemble time, reduce the test fixture cost to each test line and reduce size and weight of test fixture. For this purpose Six sigma framework was used. First Charles and his members define the problem by study the current text fixture features. They analyse that fixture move joint to joint which can create problems. Then they perform measure by analyse the design, pressure rating

• In design phase weight and size of device was improve (reduce) and finally verify phase occur to check the changes.
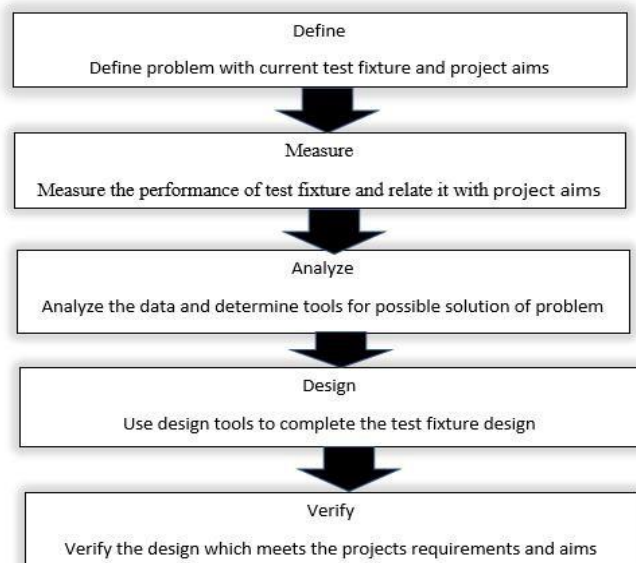

Fig. 2. DFSS Methodology
of device and handling and testing time.

• In analysis phase they apply "PCE (process cycle efficiency)" by which they improve the assemble, disassemble, handling and testing time.

Six sigma "DMAIC" approach is used for the testing of "EDA" tools. By using this approach the root cause of the problem is easily identified and the predictions of improvements have been recorded. In this approach we used the testing actions of simulation and formal based verification tools to reduce the number of defects during testing phase. There is 20 percent improvement in the early phase of "DMAIC" in testing capability to search new planning faults.

The hybrid approach of six sigma and 3D Function point is used to improve the quality of software products. In this approach we used two categories of six sigma that is "DMADV" (Define, Measure, Analyze, Design, and Verify) and "DMAIC" (Define, Measure, Analyze, Improve, Control). For the real time applications and business application 3D function point is used. The size of estimation is the main step to ensure the good quality product. For this purpose "Function Points Analysis (FPA)" is used that control external Interfaces, Internal logical files, external Inputs, external Inquiries and external Outputs which were then evaluated on a scale of 1 to 5 using 14 parameters.

"Statistical Process Control (SPC)" technique is used to control the process in food Production Company. In this technique there is a step by step guideline for the implementation. It is cyclic activities that observes the changes in the existing processes and then rebuild these processes and it is also related to the "AR" cycle because in both cycles planning is required before any action taken and then the effect of that action taken is reflected.

Different tools are used for applying six sigma to improve the discharge process of the hospital as shown in Figure. By applying these tools we can solve this problem.
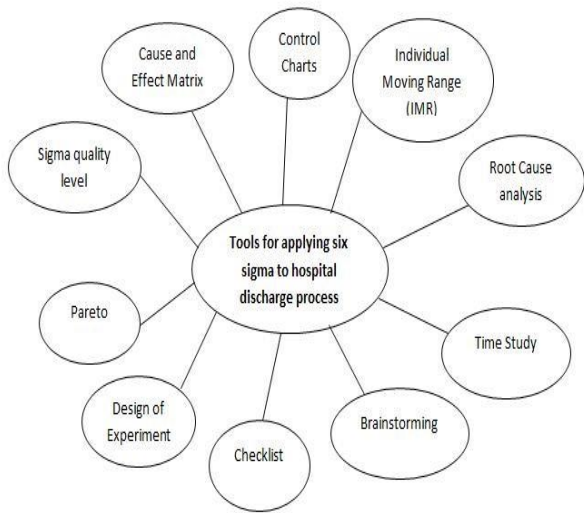

Fig. 3. Six Sigma Tools for Hospital discharge process

Lean six sigma and Fuzzy logic techniques are used to evaluate the critical success factors on the quality of processes in the field of power electrical engineering. There are two concepts of Lean Six Sigma firstly it reduces the wastes and progression times and secondly it helps companies to reduce errors. It is a structured approach that uses management and arithmetical techniques to enhance the processes of industry. "DMAIC" method is used to record Lean principles to the Six Sigma approach to recognize in what way each phase of "DMAIC" was used to fulfill a full scale Lean design effort. In the Fuzzy Logic technique we deal with the estimated reasoning and figuring with logical words. It is a rule based system used to handle the uncertainties.

IV. Conclusion

The case studies related to the improvement of quality is offered in this paper in different fields of life by applying frameworks of six sigma. Six Sigma is an effective technique that helps in solving the problem and ongoing procedure for upgrading system. In this paper we presented, in what way it actively compacts with issues related to logistics of pharmaceuticals, bank customer satisfaction, cement industry and design of hydraulic line test fixture, by determining the main complications to be solved and explaining them. And also exhibits that application development requires some tools that would not be beneficial in services assistance. Through DMAIC methodology of six sigma, limitations of project and performance is defined. The six sigma approach is practical in this study and it assures improvement in quality of education. Six sigma approach help in improving quality and reducing production cost in plastic modeling company. We implement six sigma DMAIC approach and EDA together to evaluate the efficiency of testing phase and it shows up to 20 percent upgrading to detect more defects before launching of product and also it defined the root cause of the problem. It's better to apply the six sigma approach with 3D FP to get best software processes quality and it help us to reduce modifying cost and this can also reduce the failure rate from 46.13 percent to 1 percent. In the diagnostic area the lean six sigma approach has the possibility to improve the time in problem-solving and also decreases the quantity of faults rising.

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