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Simplificaton of Six Sigma Implementation Using Shainin Tools for Process Improvement

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Abstract— The purpose of this paper is to provide a brief overview of Six Sigma and Shainin methodology and to propose the modification of Six Sigma methodology in order to achieve improved efficiency of DMAIC in the process improvement journey by using some of the Shainin tools. The success of the Six Sigma program in an organization depends to a large extent on the success of the Six Sigma project, which in turn depends on how combination of tools is being applied to address the root cause. Shainin Design of Experiments (DOE) offers powerful and effective experimental design approach for solving the chronic quality problems that plague manufacturers worldwide. The objective of this paper is to examine as to how to simplify the implementation of Six Sigma methodology by the applicability of a simpler but not very frequently used methodology known as Shainin methodology. The comparative study of various approaches of Six Sigma implementation has been done.

Index Terms— DOE, DMAIC, Process Improvement, Quality Tools, Shainin, Simplification, Six Sigma Implementation.

1 Introduction

THE demands placed on an organization in today's global business environment are driven by customer satisfaction as well as the fulfilment of the expectation of stakeholders regarding cost reduction, improving business performance and maintaining a competitive advantage. An effective quality assurance system of a company consists of three key elements: quality planning, quality control and quality improvement. One of the key factors in meeting the above-mentioned business expectations is quality improvement, the continuous improvement of quality built into the product along with the quality of the processes related to designing and manufacturing the product.

Quality improvement activities in manufacturing are in many cases focused on the reduction of process variation. In order to take advantage of emerging opportunities and to navigate in the challenging environment, manufacturers worldwide are working on robustness of their processes. Any variability in the process performance has a direct bearing on the profitability of the company. Process variation is a critical factor of process stability and therefore the cost effectiveness of the process. Thus, variability reduction is the primary requirement for defect-free production. There are two ways to reduce process variation: a) to identify and control the root-cause and b) to decrease the sensitivity of the process to the source of the variation. Growing complexity of manufacturing processes necessitated use of efficient methods for studying intricate manufacturing systems. Experimental designs (or design of experiment, DOE) are a set of statistical techniques that have long been used to identify the key input variables responsible for variations in the output.

A technical feature that distinguishes Six Sigma from other quality approaches is its ability to use statistical methods within a structured format to reduce defects and improve processes. Some of the criticisms of the Six Sigma methodology perhaps stems from the fact that it is sometimes too statistical and beyond comprehension of the people involved in implementing it in practice. The Shainin method is gaining popularity now because of the simple tools, which can give substantial good results at low cost and time. Popularly known among quality experts as Shainin System (SS), this American approach to experimental design was developed by Dorian Shainin with the same objectives as those of Classical and Taguchi DOE approach.

2 Various Approaches for Six Sigma Implementation

Pyzdek (2003) has classified Six Sigma tools into three categories, viz. Basic Six Sigma methods, Intermediate Six Sigma methods, Advanced Six Sigma methods. [3]

The basic Six Sigma tools are further categorized as problem solving tools, 7M tools and knowledge discovery tools as shown in Table 1.

Intermediate methods include a host of enumerative and analytical statistical tools.

A few enumerative statistical methods are:
- Distributions
- Statistical inference

Some of the analytical methods that can be used in Six Sigma problem solving are:
- Basic control charts
- Exponentially weighted moving average (EWMA) charts

Advanced Six Sigma methods include tools like
- Design of experiments (DOE)
- Regression and correlation analysis

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• Process capability analysis

TABLE 1
BASIC SIX SIGMA TOOLS

Problem Solving Tools	7M Tools	Knowledge Discovery Tools
Process mapping	Affinity diagrams	Run charts
Flow charts	Process decision program charts	Descriptive statistics
Check sheets	Matrix diagrams /Tree diagrams	Histograms
Pareto analysis	Interrelationship diagraphs	Exploratory data analysis
Cause-and-effect diagrams	Prioritization matrices	
Scatter plots	Activity network diagrams	

While 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. [3]

2.1 Classical Approach

Although books on Design of Experiments did not begin to appear until the twentieth century, experimentation is certainly about as old as mankind itself. The one-factor-at-a-time strategy (OFAT) was, and continues to be, used for many years. However, these experimentation strategies became outdated in the early 1920s when Ronald Fisher discovered much more efficient methods of experimentation based on factorial designs. Those designs study every possible combination of factor settings, and are especially useful when experimentation is cheap or when the number of factors under study is small (less than five). Fisher first applied factorial designs to solve an agricultural problem, where the effect of multiple variables was simultaneously (rain, water, fertilizer, etc.) studied to produce the best crop of potatoes. His experiences were published in 1935 in his book “Design of Experiments”. Fractional Factorial designs were proposed in the 1930’s and 1940’s in response to the overwhelming number of experiments that are involved with full factorial designs. This design consists of a carefully selected fraction of the full factorial experimental design. They provide a cost-effective way of studying many factors in one experiment, at the expense of ignoring some high-order interactions. This is considered to be low risk, as high order interactions are usually insignificant and difficult to interpret anyway. [1]

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. 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. [3]

2.2 Taguchi Approach

As a researcher at the Electronic Control Laboratory in Japan, an engineer known as Genechi Taguchi carried out significant research on DOE techniques in the late 1940's. Although he published his first book in Japanese in the 50’s, the standardized version of DOE, popularly known as the Taguchi Method or Taguchi approach, wasn’t introduced in the US until the early 1980's. Taguchi used and promoted statistical techniques for quality from an engineering perspective rather than from a statistical perspective. Although Taguchi has played an important role in popularising
DoE, it would be wrong to consider Taguchi Methods as just another way to perform DOE.

The basic elements of Taguchi’s quality philosophy can be summarized as follows:

1. A quality product is a product that causes a minimal loss to society during its entire life. The relation between this loss and the technical characteristics is expressed by the loss function, which is proportional to the square of the deviations of the performance characteristics from its target value
2. Taguchi breaks down his quality engineering strategies into three phases, which he calls off-line quality control: System design, Parameter design and Tolerance design. System design deals with innovative research, looking for what factors and levels should be. Parameter design is what is commonly known as Taguchi Methods. This technique is intended to improve the performance of processes/products by adjusting levels of factors. Finally, Tolerance Design aims to determine the control characteristics for each factor level identified in earlier studies.
3. Change experimentation objectives from “achieving conformance to specifications” to “reaching the target and minimising variability”.[1]

2.3 Shaininn Approach

The Shainin System is the name given to a problem solving system developed by Dorian Shainin, who died in 2000. Shainin, in 1975, established his own consulting practice: Shainin LLC. His sons Peter and Richard later joined the family business. Shainin described his colourful method as the American approach to problem solving, with the same goals of the Taguchi approach.

Dorian Shainin included several techniques- both known and newly invented – in a coherent step-by-step strategy for process improvement in manufacturing environments. Among those powerful tools, he considered Design of Experiments as the centrepiece. Moreover, he didn't believe that DoE was limited to the exclusive province of professionals, but could rather be extended so that the whole factory could be turned loose on problem-solving. The foundation of Shainin's DoE strategy rests on:

1. The Pareto Principle: Among many, even hundreds of candidate factors, a single one will be the root cause of variation of the response y. That root cause is called the Red X and may be a single variable or the interaction of two more separate variables. There may be then second or a third significant cause, called the Pink X and Pale Pink X, respectively.
2. Shainin strongly objected to the use of the Fractional Factorial technique. He proposed instead to identify and diagnostically reduce most of the sources of variation down to a manageable number (three or four), at which time he allowed the use of full factorials.
3. "Talk to the parts, they are smarter than engineers". First, talk to the parts. Then, talk to the workers on the firing line. Last, the least productive methods are to talk to the engineers. [4]

TABLE 2
COMPARISON OF CLASSICAL, TAGUCHI AND SHAININ APPROACHES

Items for comparison	Classical DOE	Taguchi DOE	Shainin DOE
Primary tools	Factorial experiments	Orthogonal arrays	a. Component search, b.Multi-vari analysis c. Paired comparison, d.Product/Process Search or, variable search, e. Full factorials, f. B vs. C (Better vs Current) analysis, Scatter plots
Advantage Effective .	When interaction effects are not present (20 to 200% improvements). Limited possibilities for optimization.	Effective when interaction effects are not present (20 to 200% improvements). Limited possibilities for optimization	Very powerful irrespective of the presence or absence of interactions. Maximum optimization possible.
Cost/Time	Moderate	Moderate	Low
Training	3 to 5 days	3 to 10 days	1 to 2 days
Complexity	Moderate	High	Low (simple & basic Mathematical operations)
Facility & Scope	Requires use of statistical software e.g., SAS, SPSS, etc.	Used mainly in preproduction & can be used at the design stage under certain constraints	Software not necessary.
Ease of Implementation	Moderate (Requires Knowledge of statistics. Engineers find methods complex to comprehend and interpret.)	Poor	High (Almost no knowledge of statistics required. Easy to understand at all levels including shop floor workers, engineers, and suppliers, thus creating an overall positive impact

3 SHAININ DOE TOOLS: AN OVERVIEW OF SELECT TOOLS

Shainin DOE basically works at eliminating suspected process variables (Xs) mostly by using seven different tools:

1. Multi-Vari Analysis
2. Component Search
3. Paired Comparison
4. Variable Search
5. Full Factorials
6. B vs. C (Better vs. Current) Analysis
7. Scatter Plots or Realistic Tolerance Parallelogram Plots.

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TABLE 3
SHAININ TOOLS

Tool	Objective	Where Applicable	When Applicable	Sample Size
Multi-vari chart	To reduce a large number of unrelated variables to a family of smaller related causes	To get a snapshot of how a product/ process is currently running	At engineering pilot run, production pilot run or in production	Min 9- 15
Components search	To determine if the Red X is in the assembly process or the components in the assembly	In assembly operations	At prototype, engineering pilot run, production pilot run or in production	2
Paired comparisons	Provide clues to determine the red X by using a paired comparison of good and bad parts	Where there are matched sets of differently performing products that cannot be disassembled	Same as component search	1 to 20

4 SHAININ SIX SIGMA FRAMEWORK

In order to integrate Shainin DOE tools and technique with Six Sigma DMAIC, the modified DMAIC framework is proposed. In this framework, the analysis phase of DMAIC process is divided into three stages viz. 'Pre-analysis', for the selection of the experimental design; 'Experiment', for running experiments and collecting data; and 'Analysis', for analysing experimental data. The tools and techniques used in this framework is given in Table 4.

TABLE 4
TOOLS USED IN SIX SIGMA METHODOLOGY

Objective Phases	Purpose	Tools used
Define	To identify and define problem, establish goals and objectives and select project team	Project charter
Measure	To identify and classify factors, validate the measurement system	Brainstorming Process mapping Shainin Isoplot
Pre-analysis	To select experimental design and tools, characterise factors and levels	Shainin DOE
Experiment and data collection	To plan and manage logistics, perform experiment and collect data	Worksheets for data collection
Analysis	To determine active primary factors, interpret results and determine solutions	Paired comparison Process search Concentration chart
Improve	To validate solutions	B vs. C (better vs. current) analysis
Control	To implement controls and evaluate experimentation iteration	Control plan Pre-control

5 CONCLUSION

1. It can be concluded that Shainin approach for Six Sigma implementation is the best approach among the three approaches.
2. The Shainin tools are simple, easy to understand and effective for simplification of DMAIC methodology of Six Sigma.
3. Six Sigma tools are complex and contain more statistical calculations and thus it takes more time for implementation in process improvement. So effective use of Shainin tools could accelerate its implementation.
4. Shainin tools could be understood at all levels even by shop floor workers, engineers and suppliers. Thus process improvement is done quickly thus reducing the overall production costs and time required for doing a process.

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