

Analyzing the need for a comparative study of Shainin DoE and Traditional DoE tools for deploying Six Sigma in Indian manufacturing companies

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Abstract: Globalization and cut-throat competition have been pushing manufacturing companies to a corner nowadays, especially in turbulent market places. Therefore, in this context, it has also become important for manufacturing companies to manage their products and processes in the most optimal manner. To enhance quality with reduction in cost, there is a need for employing Design of Experiments (DoE) tools like Taguchi method, Shainin tools and factorial method etc. as part of Six-Sigma efforts in Industries. Quality achieved by means of process optimization is found by many manufacturers to be cost effective in gaining and maintaining a competitive position in world markets. Although, Six-Sigma improvement initiative has emphasized on the use of DoE for experimentation, engineers still consider it a difficult technique to apply and interpret. The complexity of DoE techniques is often seen as the reason why they are unable to employ them in Six-Sigma. Selection of a particular approach to experimentation (i.e. Taguchi, classical or Shainin) is dependent upon a number of criteria: complexity involved, degree of optimization required by the experimenter, time required for completion of the experiment, cost issues associated with the experiment and permitted response time to report back etc. This paper concludes that a thorough study is needed in manufacturing industries to analyze and compare various DoE tools in the effective implementation of Six-Sigma, as it is also necessary to explore the concepts, definition and significance of DoE tools particularly in the application of Shainin DoE tools.

Keywords: Shainin System, Taguchi DoE, Variable Search

1. Introduction

Engineers carryout a variety of activities in manufacturing companies, such as design & development of newer innovative products, improving/modification of existing designs, maintaining, controlling and streamlining the ongoing production processes as well as maintaining and repairing of products, etc. Experimentation is very frequently used in these activities. Regardless of their background, engineers end up using a great deal of statistics in it. Though, experimentation is a regular and ongoing activity of the engineers, they often end up using primitive strategies to carry and complete their experiments. Various studies have identified and brought out the need for using strong, efficient and practical techniques needed for deploying experimentation. Six Sigma improvement initiative has emphasized on the use of techniques like Design of Experiments (DoE) for experimentation in manufacturing industries. However, many manufacturing companies still consider it as a difficult technique to apply and interpret due to their complexity. Moreover, most commercial software systems and expert systems in DoE provide no solution and guidance in classifying and analyzing manufacturing processes and



quality-related problems from which a suitable approach (such as Taguchi, classical or Shainin's approach) can be selected. Further, very little or no research has so far been done on this particular aspect and this is probably the most important and crucial part while dealing with the DoE.

2. Literature review

Goh T. N. [1] concluded in his study that DoE by Taguchi Methods have better potential to bring about break through improvements in various industrial applications. However, due to their theoretical imperfections, success cannot be guaranteed at every instance. John Goodman et al. [2] observed that the DoE Shainin's quality control approach is very practical and can easily be applied in a variety of settings and this makes it a most approachable quality tool. Jeron de Mast [3] opined that the Shainin System is mainly a problem solving methodology and its applicability is limited to projects that seek to identify the (one or very few) root causes of a problem. It is not suitable for studying a more complex process and their influential factors and also for modeling their effects onto the stage of "critical to quality" (CTQ). Jan Kosina [4] compared the three technologies i.e. Six Sigma, Shainin and Kepner Tregoe in his study The main aim of this comparative study was not to find the best technology, but to explore whether these methodologies supplement each other. He also concluded that there is a need for research on the selection of suitable tools to develop a system, which could be used for quality improvement of the products, consisting of large quantity of the components.

Sunil Sharma et al. [5] stated that the Shainin tools are simple to understand by both the engineers and shop floor workers. They are logical and are based on common sense. They are universally applicable in a wide range of Industries. Stefan H. Steiner et al. [6] observed that the Shainin system (SS) is best suited for medium to high volume production in manufacturing companies. Most of the tools in SS assume that many parts are available for study. Even when using leverage, where the investigations involve a small number of extreme parts, there must be a substantial amount of measurement to find the extremes. Like many other systems with strong statistical backgrounds, Shainin System does not handle the situations well, where there are few parts to "talk to", such as design and development of a new product or process.

Kulvinder Singh et al. [7] concluded that the Shainin DoE tools are very effective in manufacturing industries to solve the problem of process optimization. Within the world of Design of Experiments (DoE), the Shainin techniques provides the simplest, easiest and most effective ways to get the solution. Taguchi's focus on efficient response variables is an excellent, but poorly understood idea. The Shainin's quality control methodology is very practical and can easily be performed in a variety of settings. They are easy to set up, execute and require short span of time to administer [8]. The core of Shainin's method is in identifying the source of variation. This method focuses on identifying the vital few factors (product or process parameters) that have a significant effect on some desired outputs. Shainin's methods rely heavily on vast engineering knowledge and experience [9].

Jagannath Munda et al. [10] mentioned that Taguchi method is interested in finding a "robust" solution to the problem of experimentation. It seeks a solution that is insensitive to factor variations and noise. It doesn't find the best combination of factors to achieve the expected goals. Senthil and K.S. Amirthagadeswaran[11] mentioned that Taguchi method is a very efficient problem solving statistical quality tool. It can improve the performance of the product, process, design and system in manufacturing companies, with a significant reduction in experimental time and cost using an orthogonal array. This method mixes the experimental design theory and quality loss function concept, which has been used for carrying out robust design of processes and products and solving very complex quality related problems in manufacturing industries.

A survey too identified that there is a necessity of usage of an efficient and practical technique for the experimentation. The high degree of complexity of DoE techniques is frequently cited by manufacturing companies as a main reason as to why they are unable to employ them in Six Sigma projects very confidently [12].

Keki Bote [13] compared the Taguchi and Shainin DoE techniques and the same is given in Table.1.

Table 1: Comparison of Taguchi and Shainin DoE.

Characteristic	Taguchi	Shainin
Technique	Multi array.	Multi-Variate, variable search, full factorials.
Effectiveness	Low to moderate. Retrogression likely.	Extremely powerful. No retrogression.
Cost	High	Low
Complexity	High	Low
Statistical validity	Poor	High
Applicability	Primary use as a substitute for Monte Carlo Analysis.	Can be used as early as prototype and engineering run stage.
Ease of implementation	Difficult	Easy

Jeroen De Mast et al.[14] concluded that various Statistical Process Control (SPC) and Six sigma strategies could supplement each other and their rigid application of either SPC or six sigma program to a given project is not optimal. Taguchi Method (TM) is an experimental method, which aims at finding optimal values for the parameters in the process and the Shainin system is the only strategy that has elements of stabilization & optimization approach, although this difference is not made explicitly. The Taguchi approach is a DoE method used in many manufacturing industries for creating new products. Taguchi's specially designed method of orthogonal array is applied to select final design with an aim to conduct few trials of experiments [15]. According to Vagh and Pandya [16] Taguchi techniques have been widely applied for optimization in material processing and recently it has emerged as a proven technique.

Justin T. Aichail et.al.[17] concluded in their study that the Shainin approach for Six Sigma implementation is the best approach among the Taguchi and classical approaches and Shainin tools are simple, easy to understand and effective for simplification of DMAIC methodology of Six Sigma. The TM is a known, unique and most powerful technique for product/process quality improvements in manufacturing companies. It is widely used for the analysis of experimentation and product/process optimization. The application of the TM is not limited to any specific problem. It has been successfully applied in many industrial organizations and which has completely changed their outlook on quality control [18].

Shainin techniques are primarily known to produce continuous improvements by eliminating chronic quality problems. These are highly effective in pinpointing the root cause and validating it. Statistical software is not needed to analyze the given data. In fact, Shainin DoE does not even require any knowledge of difficult statistical tools. It involves simple operations like counts, additions,

subtractions, etc. The success of the Six Sigma projects using Shainin method could lead to a very positive effect on the morale of the employees in terms of convincing them that Six Sigma can be implemented very easily without complex statistics and big jargons [19].

According to Howell, David [20], the message seems to be: use Taguchi by all means, but be aware of its limitations. Also be aware of the wider set of powerful experimental design and analysis methods. Andrew Metcalfe, of the University new castle's department of engineering mathematics mentioned that there are three criticisms of the Taguchi method, which are: 1) They tend to assume that interactions are negligible. 2) Accumulating analysis is likely to indicate that some variables have an effect, even if this appearance is just due to chance and 3) The signal to noise ratios may not be an appropriate response to analyse. Most experts accept that the Taguchi methods are flawed. Some say even that they are dangerous. Yet many engineers are happy in using Taguchi methods [20].

Anupama Prashar [21] concluded in her paper that shainin DOE methods are easy to learn and can be applied to ongoing processes during full production. However, the effectiveness of these experimental design methods depends upon the ranking of factors and assignment of best and worst levels. Furthermore, Shainin DOE approach focuses on the analysis of mean response only, rather than analyzing mean and variability as two different responses. This approach appropriate only for processes already at high level of stability and capability. There is a scope for more research on this approach, particularly on its adoption for service process optimization.

Srinivasan Balan [22] concluded in his study that Shainin DoE is a simple approach to solve all optimization problems. A wide range of tools are in this method for problem solving as well as optimization. Although the multi response problems are concerned, Shainin approach is the same as a single response problem. The DoE by Shainin Method could result in more than 70% reduction in the variation by removing negative reasons i.e. long lasting experiments and complicated computations. The basic point of the method, which has its own tools, is to determine the important factors causing variations (Red X, Pink X, and Pale Pink X) that are eliminating unimportant factors. Thus, net results can be reached by applying full factorial experiment. Taguchi Method is an experimental design technique that reduces the number of experiments significantly by using the orthogonal arrays and also that tries to minimize the effects of the uncontrollable factors [23].

Taguchi method is used to provide an efficient design of experiment technique to obtain simple, systematic and efficient methodology for the optimization of the cutting parameters [24]. Meeran Mohideen V, Kesavan [25] stated in their study that Component search tool of Shainin DoE helps to narrow down to the components which cause the problem, ideal for assembly problems as this tool can be used for assemblies, where reassembly is possible without any damages. Assembly problems can be due to the assembly process or the components interactions between components also lead to the problem. Always select one very BEST assembly and one VERY worst assembly for the study. They also concluded that Shainin way of DoEs is helpful to identify the suspected source of variation without ambiguity. Paired comparison tool of Shainin DoE is used to identify the product and process characteristics contributing to the run out. Full factorial analysis is another tool in Shainin DOE that can be used to optimize the process parameter.

3. Hypotheses

As a result of the extant literature review conducted and the analyses, the following hypotheses are formed.

1. Shainin system cannot handle situations involving the design and development of processes effectively.
2. Traditional DOEs (Taguchi and RSM) can handle well the situations involving the design and development of new products or processes.

3. Shainin system is not suitable in the administration department of manufacturing firms while deploying six sigma.
4. Semi-skilled workers can understand and handle Shainin method very easily in manufacturing firms.
5. Semi skilled workers cannot handle traditional DOEs (Taguchi and RSM) very easily in manufacturing firms.
6. Shainin DOE tools are found more suitable in Small scale manufacturing companies, while deploying six sigma.
7. Traditional DOEs (Taguchi and RSM) are not found suitable for small scale manufacturing companies, while deploying six sigma.
8. Traditional DOEs (Taguchi and RSM) ensure breakthrough improvements in manufacturing firms.
9. Application of Shainin DOE does not ensure breakthrough improvements in manufacturing firms.
10. Application of Shainin DOE ensures continuous improvements manufacturing firms.
11. Traditional DOEs (Taguchi and RSM) do not ensure continuous improvements in manufacturing firms.
12. Traditional DOEs (Taguchi and RSM) are highly suitable for medium to large scale companies, while deploying six sigma in manufacturing firms.
13. Traditional DOEs (Taguchi and RSM) are found suitable in administration department of manufacturing firms while deploying six sigma.

4. Methodology

In order to test the conceptualized hypotheses and validate the same, the following methodology is proposed to be followed. To carry out the initial analysis and also to check the validity and applicability of various tools/methodology, few case studies are proposed to be conducted in select manufacturing industries. Case studies are in many cases accused of lack of rigor, meaning they provide very little basis for scientific generalization and is also labelled as being too long, difficult to conduct and producing a massive amount of documentation. Subsequent to the case studies, it is proposed that further data collection be done in select manufacturing industries in connection with various processes & Products and in connection with the use and applications of Traditional DoE tools and Shainin DOE tools. A comparative study of Traditional and Shainin DoE tools with respect to strategies of select manufacturing industries deploying Six Sigma is expected to form the basis for the selection of these industries and for subsequent plan for data collection. In view of this, a questionnaire is further proposed to be prepared for gathering primary data from Top, Middle management and skilled workers of different manufacturing industries so as to statistically test, validate and confirm the conceptualized hypotheses.

5. Conclusions

Based on the extant literature survey and further analyzes on the topics of Traditional and Shainin DoE tools in manufacturing industries, it can be concluded that there is a need to explore and compare thoroughly the concepts, definition and significance of Traditional DoE tools as well as analyze and find out the pertinence and applicability of Shainin DoE tools in manufacturing industries in India. It is also important to select an appropriate DoE tool for dealing with various situations as there is a need to identify the best DoE tool that could be used to increase the predictability and consistency in Process and Product Quality improvement. It is also useful and advisable to evaluate the Traditional and Shainin DoE tools for maintaining Six sigma level in Product and Process Quality in the selected manufacturing companies. The hypothesized conceptual frame work is required to be validated and confirmed to establish the findings.

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