Optimization Using Taguchi Design of Experiments

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Abstract: Taguchi approach is a new experimental strategy in which utilizes a modified and standardized form of Design of experiments. Taguchi design of experiments provides a higher level of quality in products and services to increase market share and profits. Taguchi DOE provides the quality achieved by means of design of optimization is found by many manufacturers to be cost effective in gaining and maintaining a competitive position in the world market. This paper compares the Taguchi DOE and with their advantages and limitations.

Keywords: Sample Size, Randomization, Optimization, Response Surface Methodology, Orthogonal Array (OA).

I. INTRODUCTION

Genichi Taguchi, a Japanese engineer, proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." These methods utilize two-, three-, and mixed-level fractional factorial designs. Large screening designs seem to be particularly favored by Taguchi adherents. It is being adopted to understand the effects of drilling inducedExpected range of the outputresponse for the optimum inputparameters utilizing the modifiedTaguchi approach (Rajyalakshmi K, Nageswara Rao Boggarapuet al., 2018). Taguchi refers to experimental design as "off-line quality control" because it is a method of ensuring good performance in the design stage of products or processes. Some experimental designs, however, such as when used in evolutionary operation, can be used on-line while the process is running. Off line QC refers to the improvement of quality in the product and process development stages. On-line QC refers to the monitoring of current manufacturing processes to verity the quality levels produced. Taguchi" designs are similar to our familiar fractional factorial designs. However, Taguchi has introduced several noteworthy new ways of conceptualizing an experiment that are very valuable, especially in product development and industrial engineering, and we will look at two of his main ideas, namely Parameter Design and Tolerance Design, excluding these we have system design also. Taguchi contributed discipline and structure to the design of experiments. The result is a standardized design methodology that can easily be applied investigators. Furthermore designs for the same experiment by two different investigators will yield similar data and will lead to similar conclusions. Taguchi overcame the limitations of factorial and fractional factorial experiments. In system design the engineer applies scientific and engineering knowledge to produce a basic functional prototype design. The objective of the parameter design is to optimize the settings of the process parameter values for improving performance characteristics and to identify the product parameter values under the optimal process parameter values as shown in Fig.1. The parameter design is the key step in Taguchi method to achieving high quality without increasing cost. The steps included in the Taguchi parameter design are: Selecting the proper orthogonal array (OA) according to the numbers of controllable factors(parameters) ; running experiments based on the OA; analyzing data: identifying the optimum condition and conducting confirmation runs with the optimal levels of all the parameters. It can be explained in the following diagram.

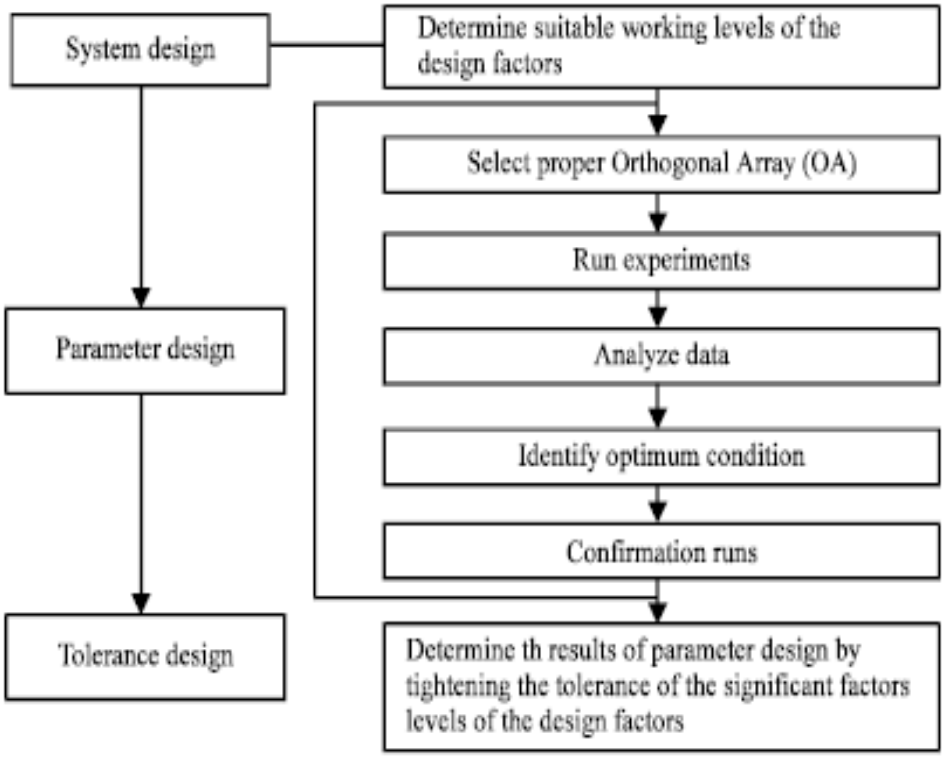

Fig.1. Taguchi Design.

A. The need and importance of Taguchi Design of Experiments

The concept such as quality should be designed into the product, quality loss function, determining the optimization condition for the product or process, designing product and process that insensitive to the influence of uncontrollable factors or noise, signal-to-noise ratio and orthogonal arrays.

Summary of Literature Review:

Name	Paper Name	Description
Ross, P.J.(1989)	Taguchi Technique for Quality Engineering	It demonstrates that precise confidence interval estimates can be obtained using the proposed ANOVA model like approach.
Sai Somanadh Sastry Konduri, VDSR Manideep Kumar Kalava	Application of Taguchi approach to seek optimum drilling parameters for woven Fabric carbon fibre/epoxy laminates	An efficient prediction methodology is considered to estimate the output responses for the identified optimum drilling parameters and validated through comparison of test results.
J. Singarevelu, D. Jeyakumar and B. Nageswara Rao, 2009	Taguchi approach for reliability and safety assessments in the stage separation process of a multi stage launch vehicle.	It demonstrates the applicability of Taguchi method to capture the essential Monte-Carlo simulation results in the stage separation process. It is useful to understand the dynamic behavior of the separating bodies during the stage separation process of multi stage launch vehicles.
J. Singarevelu, D. Jeyakumar, B. Nageswararao	Reliability and safety Assessment of the Satellite separation process of a typical launch vehile.	The RSM results are compared with the Taguchi simulation results. Reliability and safety assessments are made on the satellite separation of a typical launch vehicle.
P.Bharathi, Gouri Lalitha Priyanka, G. Srinivasa Rao, Boggarupu Nageswara Rao	Optimum WEDM process parameters of SS304 using Taguchi method	A multi objective optimization method is adopted here to trace the optimum WEDM process parameters for achieving sufficiently high material removal rate and low surface finish as well as the kerf width.(Wire Electrical Discharge Machining)

Benefits of Taguchi DOE:

M. Aghakahani, E.Mehradab and E-Mayathi (2011)	Parametric optimization of Gas Metal Arc Welding process by Taguchi Method on Weld dilution	Using DOE a mathematical model was developed using parameters such as wire feed rate (W), Welding Voltage (V), and predicting the weld dilution was obtained.
Sai Somanath Sastry K	Application of Taguchi approach to seek optimum drilling parameters for woven fabric carbon/fibre/epoxy laminates.	An efficient prediction methodology is considered to estimate the output responses for the identified optimum drilling parameters and validated through comparison of test results.
M. Sahiti, M.Raghavendra Reddy.	Optimum WEDM process parameters of Incoly R Alloy 800 using Taguchi method.	A simple multi objective optimization approach is suggested for specifying a set of optimum input parameters to achieve maximum material removal rate, and minimum surface finish and kerf width.
Mumin Tutar, Makan Aydin	Multi objective Taguchi optimization approach for resistance spot welding of cold rolled TWIP steel sheets	The effect of welding parameters was also evaluated by examining the signal – to – noise ration and ANOVA results.
Anam Asghar, Abdul Azia Abdul Raman, and Wan Mohd Ashri Wan Daud	A comparison of central composite Design and Taguchi method for optimizing Fenton process	From a comparative study it is concluded that Taguchi method with 9 experimental runs and simple interaction plots is a suitable alternative to CCD for several chemical engineering Applications
George. J. Besseries	Taguchi – generalized regression neural network (GRNN) micro –screening for physical and sensory characteristics of bread.	The purpose of this study is to synthesize an intelligent instrument to aid the 'smart and robust' data analysis of complex processes.

Success Criteria for Taguchi Implementation:

Ali Azadeh & Seyed Sina Miri-Nargesi & Seyed Mortezza Goldansaz & Nima Zoraghi(2018)	ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated	The results indicated that the structure and modeling approach of this paper could be easily utilized for managerial and organizational ranking and analysis of other sectors

	Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems ORIGINAL ARTICLE Design and implementation of an integrated Taguchi method for continuous assessment and improvement of manufacturing systems Design and implementation of integrated Taguchi method for continuous assessment and improvement of manufacturing systems.	
Pinki Maurya1 , Dr. Pankaj Sharma2 , Bijendra Diwaker	Implementation of Taguchi methodology to Optimization of CNC end milling process parameters of AL6351 –T6	In this paper we have study on CNC end milling, influence of various machining parameters like, tool feed (mm/min), tool speed (rpm), tool diameter (mm) and depth of cut (mm). In the present study, experiments are conducted on AL 6351 –T6 material with three levels and four factors to optimize process parameter and surface roughness. An L9 (3*4) Taguchi standard orthogonal array (OA) is chosen for design of experiments and the main influencing factor are determined for each given machining criteria by using Analysis of variance (ANOVA).)

II. METHOD LIMITATIONS

Advantages:

- An advantage of the Taguchi method is that it emphasizes a mean performance characteristic value close to the target value rather than a value within certain specification limits, thus improving the product quality.
- Additionally, Taguchi's method for experimental design is straightforward and easy to apply to many engineering situations, making it a powerful yet simple tool.
- It can be used to quickly narrow down the scope of a research project or to identify problems in a manufacturing process from data already in existence.
- Also, the Taguchi method allows for the analysis of many different parameters without a prohibitively high amount of experimentation.

Disadvantages:

- The main disadvantage of the Taguchi method is that the results obtained are only relative and do not exactly indicate what parameter has the highest effect on the performance characteristic value.
- Also, since orthogonal arrays do not test all variable combinations, this method should not be used with all relationships between all variables are needed.
- The Taguchi method has been criticized in the literature for difficulty in accounting for interactions between parameters.
- Another limitation is that the Taguchi methods are offline, and therefore inappropriate for a dynamically changing process such as a simulation study.
- Furthermore, since Taguchi methods deal with designing quality in rather than correcting for poor quality, they are applied most effectively at early stages of process development.
- After design variables are specified, use of experimental design may be less cost effective.

III. CONCLUSION

This paper illustrates the application of the parameter design (Taguchi method) in the optimization of facing operation. The following conclusions can be drawn based on the above experimental results of this study:

- Taguchi's Method of parameter design can be performed with lesser number of experimentations as compared to that of full factorial analysis and yields similar results.
- Taguchi's method can be applied for analyzing any other kind of problems as described in this paper.

- It is found that the parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for optimizing the process parameters.

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