

RESEARCH ARTICLE

ESSENCE OF THE TAGUCHI AND GRA METHOD IN OPTIMIZATION OF CUTTING PARAMETERS: A REVIEW

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ARTICLE DETAILS

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ABSTRACT

Nowadays, there is a drastic competition in manufacturing industries to provide the finest quality to the consumers with minimized production cost. Various processes are used for machining of different materials accordingly. But there are some major challenges which arise in machining of various alloys like poor surface finish, circularity error, burr formation etc. Different producers are adapting different techniques to optimize these features. This paper reviews different techniques used by researchers but it is observed that the taguchi with grey relational analysis is extensively used.

KEYWORDS

Taguchi method, GRA, optimization, ANOVA

1. INTRODUCTION

The essence of manufacturing industry comes from raw materials. The raw materials are converted into useful form called product to fulfill the demand of the consumer. This conversion of raw material to product is called manufacturing process. These processes are of different types used accordingly in the industries. Casting, machining, forming, fabrication, surface finish treatments etc. are some of the processes used in the manufacturing industry. But every process has its own limitations which lead to poor quality sometimes. Hence, it becomes a necessity to study the optimization techniques of the process parameters.

1.1 Problems faced by industries

As we all are aware of the drastic competition in manufacturing hub to satisfy the requirements of the consumer due to 'n' numbers of varieties available in the market of the identical product at affordable cost. In Modern Times, to satisfy a customer with quality and cost both; is a huge challenge. To fulfill this, there are some factors to be kept mind before production:

- Minimum time should be taken for delivery of the product
- Availability of the product in the market
- Least possible cost of the product
- Product should be excellent in terms of quality
- Life of the product should be satisfying
- After- sale support should be good

1.2 Manufacturing parameters to keep in mind

To overcome the above-mentioned problems, following considerations should be taken into account:

- The raw material should be of fine quality
- Raw material should be smoothly available

- Cost of production should be less
- Time of production should be less
- Manufacturing operation should be selected according to the product
- Production rate should be maximum in minimum time
- Tool life, MRR, surface finish etc. should be high

1.3 Optimization techniques

There are many techniques used by researchers to optimize the machining parameters of the operation which are as follows:

- Genetic algorithm
- Taguchi and grey relational analysis
- Simulated annealing
- Particle swarm Optimization
- Nelder-Mead simplex method
- Hybrid differential evolution algorithm
- Cuckoo search
- Nature algorithm
- Shuffled frog leaping etc

2. LITERATURE REVIEW

To optimize the process parameters, different techniques used in literature review are shown in the following Table 1.

Om Prakash Singh et al performed an experiment by applying the taguchi based GRA method to optimize the shoulder milling process parameters (Singh et al., 2019). The research represents that in the optimization of cutting parameters of Al 6063, feed rate contributes the most. Arshad Noor Siddiquee et al emphasized on the optimizing the drilling operation with the help of the taguchi approach (Siddiquee et al., 2014). The

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experimental results revealed speed is the most important factor for surface roughness. The taguchi technique has been widely used in various analyses and by applying it, the time required for investigations can be saved. Avinash A Thakre and Julie Z Zhang et al used the taguchi technique to optimize the surface quality in different machining processes (Thakre, 2013; Zhang et al., 2008). M Saravanan et al applied genetic algorithm for optimizing the drilling parameters (Saravanan et al., 2012).

cutting forces. M S Sukumar et al applied the taguchi approach for identification of the optimum conditions in milling of aluminium 6061 (Sukumar et al., 2014). An ANN (Artificial Neural network) most developed for the value of surface roughness. Gaurav Kumar et al milled SS304 and optimized the machining parameters using taguchi method (Kumar et al., 2021). Mukesh Kumar et al optimized the deep drilling parameters using taguchi and GRA (Kumar et al., 2021). O. P. Singh et al studied different techniques of optimization and concluded the taguchi is widely used for optimization (Singh et al., 2019). The frequency of the different methods applied by researchers for optimization is given in the following table 2 and figure 1.

Table 1: Literature review			
No.	Author	Field of research	Methodology
1	Singh et al., 2019	Shoulder milling process parameters	Taguchi with GRA
2	Siddiquiee et al., 2014	Deep drilling parameters	Taguchi with GRA
3	Thakre, 2013	Milling process parameters	Taguchi with GRA
4	Zhang et al., 2008	Drilling process parameters	Taguchi with GRA
5	Saravanan et al., 2012	Drilling operation parameters	Genetic Algorithm
6	Cicek et al., 2012	Drilling parameters	Taguchi with GRA
7	Akhil et al., 2016	Drilling process parameters	Taguchi with GRA
8	Kannan et al., 2014	Drilling parameters	Genetic Algorithm and Particle swarm optimization
9	Lee et al., 1998a	Drilling operation parameters	Simulated annealing
10	Lee et al., 2020b	Milling process parameters	Nelder simplex method Mead
11	Subramanian et al., 2013	Shoulder milling process parameters	Genetic algorithm using RSM
12	Sukumar et al., 2014	Milling operation parameters	Taguchi with ANN
13	Kumar et al., 2021	End milling operation parameters	Taguchi with GRA
14	Kumar et al., 2021	Deep drilling operation parameters	Taguchi with GRA
15	Singh et al., 2019	Different machining operations	Taguchi with GRA

Carbon fiber reinforced plastic composite what's taken for experiment. Using this approach 10% variation is noticed when compare two numerical methods. Adem Cicek et al investigated the drilling parameters and observed the effects of cryogenic treatment on surface finish and circularity lapse in drilling of SS 316 using taguchi technique (Cicek et al., 2012). It was observed that speed contributes the most to minimize the roughness and roundness error. Akhil K.T et al tried to optimize the drilling characteristics using GRA. Glass reinforced polymer is chosen as material noticing the increment in its use in automotive industry (Akhil et al., 2016). T. Deepan Bharathi Kannan et al applied ANN modelling to optimize the machining parameters of drilling (Kannan et al., 2014). A comparison between application of genetic algorithm and particle Swarm Optimization is shown in the study.

B Y Lee et al optimized the drilling process simulated annealing (Lee et al., 1998a). It is found that there is less than 10% prediction error off tool life. Yubin Lee et al. applied Nelder-mead simplex method for optimization of the cutting parameters of milling operation (Lee et al., 2020b). A 30% profit improvement was observed by applying this approach. M Subramanian et al made a statistical model for prediction of cutting forces using RSM and genetic algorithm (Subramanian et al., 2013). Aluminium 7075 T6 was shoulder milled and a dynamometer was used to measure

Table 2: Frequency of methods		
No.	Method	Frequency
1	The Taguchi method	9
2	Genetic Algorithm	3
3	Simulated annealing	1
4	Nelder Mead simplex method	1
5	Particle swarm optimization	1

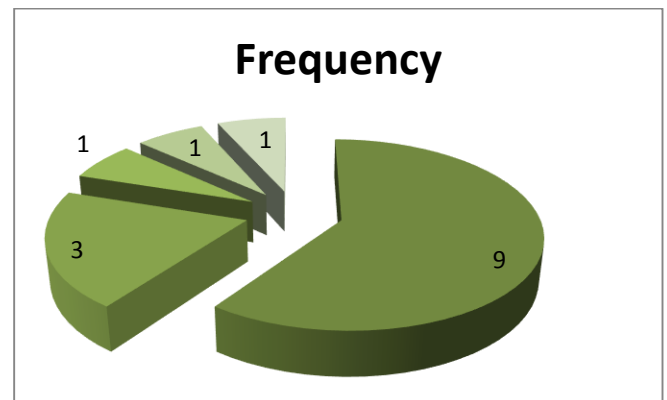


Figure 1: Frequency of methods used

2.1 Taguchi method

It is a statistical approach given by Dr. Genuchi Taguchi to enhance the quality of the product. The key step of taguchi is to achieve great quality without variation in cost. Parameters selected have to be least sensitive to variations of noise factors (human error, temperature etc.). As 'n' number of experiments need to be performed, this approach applies a matrix design called orthogonal arrays.

Then, a loss function is calculated to know the difference between predicted value and experimental value and further transformed into S/N ratio. Generally, there are 3 types of S/N ratio: "nominal- the-better, lower-the-better and higher-the better". In case of multi performance characteristics overall analysis of S/N ratio is required. For the overall evaluation, grey relational analysis (GRA) is adopted. The foremost step of GRA is the grey relational generation. In this step, the data is preprocessed and then normalized in the range of 0 and 1. From this data, the grey relational Coefficient is calculated and averaging is done to find the grey relational grade. After averaging the data, the optimization of multi objective performance characteristics is transformed into a single attribute. The higher grey relational grade gives the optimal level of cutting parameters. Further, analysis of variance (ANOVA) is done to find which parameter is most significant. Finally, to verify the results a confirmation test is conducted.

Based on the above explanation the taguchi approach with GRA includes the following steps:

2.1.1 Planning of experiment

- Identification of cutting parameters and performance characteristics
- Identification of control factors and number of levels
- Selection of appropriate matrix and defining of data analysis process

2.1.2 Run the experiment

2.1.3 Analysis and verification of data

- Analyze the data and normalize the experiment

- Grey relational Coefficient must be calculated
- Grey relational grade must be calculated
- ANOVA should be calculated
- Identification of effective levels of machining parameters
- Conduct the confirmation test

The flow diagram of the taguchi method is shown below in figure 2:

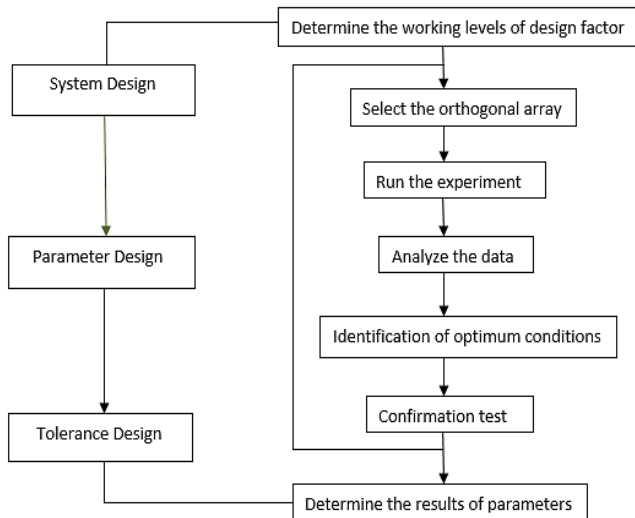


Figure 2: Flow chart

3. CONCLUSION

There are various techniques used by researchers like simulated annealing, genetic algorithm, particle Swarm algorithm, Nelder-Mead simplex method, taguchi method etc. Among all these techniques, it is observed that the taguchi method is frequently applied for optimization of manufacturing processes. Most of the researchers did not give a clear justification for applying different optimization techniques but from the literature review, it is clear that the taguchi with grey relational analysis is the best optimization technique used for years and always been the first choice to optimize the multi performance characteristics.

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