© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 07 Issue: 09 | October – December 2016
Paper is available at www.jrps.in | Email : info@jrps.in

Impartial Compound Optimization of Parameters Using EDM Tool Rotation

Deepak,
Department of Automobile Engineering, GBPIT,
Govt. Of NCT of Delhi, DTTE (INDIA)
E-mail: ali10.sharma @gmail.com

Abstract: Electrical discharge machining (EDM) remains unique of the advanced methods of machining. Most publications on the EDM process are directed towards non-rotational tools. Except rotation of the tool provides a good flush effect in the machining zone. Optimization of process parameters in rotary EDM to arrive at the best manufacturing conditions is an essential need for industries towards manufacturing of quality products at lower cost. This paper aims to investigate the optimal set of process parameters such as work piece polarity, current, pulse ON and OFF time and tool rotational speed in rotary EDM process to identify the variations in three performance characteristics such as material removal rate, tool wear rate and surface roughness value during machining of P20 die steel using copper electrode. Based on the experiments conducted using L18 orthogonal assortment, analysis has been carried out with Grey relational analysis. Response tables and graphs were used to find the optimal levels of parameters in rotary EDM process. Confirmation experiments were carried out to validate the optimal results. Thus the machining parameters for rotary EDM were optimized for achieving the combined objectives of performance characteristics on the work piece material. The obtained results show that the Grey relational Analysis is being effective technique to optimize the machining parameters for EDM process. **Keywords:-** Electrical Discharge Machining (EDM), Material Removal Rate (MRR), Rotary EDM, Surface.

I. Introduction

Being systematic application of the design and analysis of experiments, Taguchi method can be used for the purpose of designing and improving the product quality. During the research and development in recent years, the Taguchi method has become a powerful tool for improving productivity so that high quality products can be produced quickly with affordable cost. But, the Taguchi method has been designed for the optimization of a single performance characteristic. For the EDM process higher-the-better performance characteristic is material removal rate (MRR). However, surface roughness (SR) and tool wear rate (TWR) etc. are lower-the-better performance characteristics. As a result, improvement in one performance characteristic will degrade another performance characteristic.

II. Literature Survey

Hence optimization of the multiple performance characteristics is much more important, but complicated than that of a single performance characteristic optimization. In this work, the orthogonal array with grey relational analysis is used to investigate the multiple performances Characteristics in Rotary EDM of P20 die steel. Many studies have proved that rotation of the electrode had great impact on the EDM process. Rotation of the tool electrode (Rotary EDM) is an important gap flushing technique that can improve the performance of the machining process [1][2][3][4]. Lot of optimization researches has been carried out in die sinking EDM process. But the distinct advantages of the Rotary EDM process is the reason for choosing this technique in die sinking process for this paper [5][6]. P20 steel is very widely used for manufacturing of dies and moulds. The characteristics of the P20 steel such as distinctive hardness, resistance to abrasion, and resistance to deformation at elevated temperatures made this material an important one in the manufacturing of many core sub-inserts in the plastic injection moulding. In this paper, the optimization of parameters considering multiple performance characteristics of the EDM process to P20 die steel using Grey relational analysis is reported. Performance characteristics selected for the evaluation of the machining effects were MRR, TWR and SR. Those process parameters that are closely correlated with the selected performance characteristics in this study are work piece polarity, discharge current, pulse on time, pulse off time and rotational speed of the tool electrode. Based on the appropriate orthogonal array, experiments are conducted first. The normalized experimental results of the performance characteristics are then used to calculate the coefficient and grades according to grey relational analysis. Optimized process parameters that simultaneously lead to higher MRR and lower TWR, SR are then verified through a confirmation experiment. Multiple Objective Optimizations of Parameters in Rotary EDM of P20 Steel

III. Experimental Procedure.

3.1 Design of Experiments:-

The application of design-of-experiments (DoE) requires careful development, prudent layout of the experiment, and connoisseur examination of the results. Taguchi has standardized methods for each of these DoE relevance steps. This approach during finding factors that influence a product in a DoE can dramatically reduce the number of trials required to gather obligatory data. Thus, DoE with Taguchi loom has become a much more attractive tool to practicing engineers and scientists.

3.2 Machining parameters selection:-

A sequence of experiments were performed on an Electrical Discharge Machine CSTL EDM FLUID SE 180 was worn as the dielectric fluid. A jet flushing classification was used the electrolytic cylindrical copper rod of 10 mm diameter (Ø10X15mm) and work piece of P20 die steel (Ø10X15mm) worn in this work 350 Sp P20 Copper Work Piece (P20) in addition to Tool Electrode (Copper) The machining parameters well thought-out in this project were work piece polarity, discharge current, pulse on time, pulse off time and rotation of the tool electrode. there are discharge current with levels of 5, 7, 9 amp pulse on and off time with levels of 100, 50, 25 µs and tool rotation speed with levels of 0, 45, and 90 RPM. Furthermore many past researchers have exposed that division of the electrode had important effect on material removal rate, tool wear rate and surface roughness. Therefore work piece polarity with positive and negative levels were also selected as one of the machining parameters. Parameters in Rotary Edm of P20 Steel DOI: 10.9790/1684-13144149 Response parameters Material Removal Rate (gm. /min.) Tool Wear Rate (gm. /min.) Surface Roughness (µm) organize parameters Levels 1 2 3 exertion piece polarity Positive Negative Discharge current (A) 5 7 9 Pulse on time (µs) 100 50 25 Pulse off time (µs) 100 50 25 Tool rotation (RPM) 0 45 90 Table1. Response parameters and control parameters with their level.

3.3 Machining performance evaluations:-

Response variables namely MRR, TWR and SR were used for the assessment of the machining concert The MRR and TWR were considered based on the weight difference of the work piece and the tool, before and after undergoing the EDM process. A high precision electronic weighing balance shown in figure INFRA having competence Max: 200 gms, readability 0.1mg was used for this function. MITUTOYO SJ 410 the MRR and TWR were considered using the following formula. MRR=work piece volume loss/machining time (gm. /min.) (1) TWR=electrode volume loss/machining time (gm. /min.) (2) The surface roughness measurement was carried out using MITUTOYO SJ 410 surface roughness testing machine. A test length of 4.8 mm was used during the measurement. Surface roughness is premeditated by averaging the centre line surface roughness values. To evaluate the EDM process efficiently the MRR and TWR, SR are regarded while "larger-the-better" and "smaller-the-better" characteristics, respectively, in this study.

3.4 Selection of the orthogonal array:-

Total degrees of freedom needs to be computed for the selection of an appropriate orthogonal array needed for the experiment. The degrees of freedom are defined as the number of comparisons between machining parameters that could do with to be made to conclude which stage is better and exclusively how to a great extent recovered. Four level machining parameter counts on behalf of three degrees of freedom. In this study, there are 9 degrees of freedom owing to one two-level machining parameter and four three echelon machining parameter in the EDM process. The next step after manipulative the degrees of freedom is the variety of the appropriate orthogonal array for the specific task. For the orthogonal array, the degrees of freedom should be greater than or at least equal to those for the machining parameters. In this paper, an L18 orthogonal array is used because it has 17 degrees of freedom, which is superior than 9 degrees of freedom in the preferred machining parameters. This array consists of eight columns and eighteen rows and it can handle one two intensity machining parameter and seven three level machining parameters at the majority. Each machining parameter is assigned to a editorial and 18 parameter combinations are required. Therefore, only 18 experiments are needed to study the entire machining parameter Multiple Objective Optimizations of space using the L18 orthogonal array. The experimental layout for the machining parameters using the L18 orthogonal array.

IV. Grey Relational Analysis of the Experimental Data.

Optimization of the process parameters is the key step in the Taguchi method to realize high quality without increasing cost. A special design of the orthogonal arrays is used in the Taguchi method to study the intact process parameter freedom with small integer of experiments. In this method the digression between experimental value and the desired value is calculated through essential loss function. Followed by the value of the loss function is further distorted in to signal-to-noise ratio (S/N ratio). Frequently there are three categories of the concert characteristics in the analysis of the S/N ratio, lower-the-better, higher-the-better and nominal-the better. Then the level with highest S/N ratio is the optimal level of the process parameters. But this is suitable for the optimization of single performance characteristic. However, the optimization of the multiple performance characteristics cannot be straight forward and simple like optimization of a single performance characteristic. The higher S/N ratio for one performance characteristics may correspond to the lower S/N ratio for an additional characteristic. As a result, generally evaluation of the S/N ratio is required for the optimization of the compound performance characteristics. To solve this problem, the grey relational analysis is adopted in this work. Experimental results using an L18 orthogonal array and performance results were shown in Data pre-processing in grey relational analysis data pre-processing is used since the range and unit in one data sequence may differ from the others. Data pre-processing is also required when the sequence scatter range is too large, or when the directions of the target in the sequence are different. The process of transferring the original sequence in to a comparable sequence is called data pre-processing [9][10]. Here the experimental results are normalized in the range between zero and one. The different steps involved in the grey relational analysis.

Figure 3(a) weighing machine Figure 3(b) MITUTOYO SJ 410

Exp .	parameter				
	A	B	C	D	E
1	1	1	1	1	1
2	1	1	2	2	2
3	1	1	3	3	3
4	1	2	1	1	2
5	1	2	2	2	3
6	1	2	3	3	1
7	1	3	1	2	1
8	1	3	2	3	2
9	1	3	3	1	3
10	2	1	1	3	3
11	2	1	2	1	1
12	2	1	3	2	2
13	2	2	1	2	3
14	2	2	2	3	1
15	2	2	3	1	2
16	2	3	1	3	2
17	2	3	2	1	3
18	2	3	3	2	1

Design Matrix of L18 Orthogonal Array Exp. No Work piece division Current (A) Pulse on time (µs) Pulse off time (µs) Tool rotation (RPM) MRR (gm./min.) TWR (gm./min.). Experimental results the normalized investigational results for MRR, higher-the-better characteristic can be articulated as min / (max min) For TWR and SR, smaller-the-better uniqueness the normalization can be done by using where the experimental result for the normalized results is for MRR, SR and TWR. The larger normalized results correspond to the better performance and the best result should be equal to one [9]. Fig.1. steps of grey relational analysis to optimize the process with multiple performance characteristics. Then the deviation sequence of each performance characteristics could be calculated by subtracting processed values from one. the deviation sequence. Multiple Objective Optimizations of Parameters in Rotary Edm of P20

4.2 Computing the Grey relational coefficient and the grey relational grade. The pre-processed sequence could be used for the calculation of grey relational coefficient after the data pre- processing. It expresses the relationship between the ideal and actual normalized experimental results. The grey relational coefficient can be expressed where, is the minimum value among the deviation sequence and is the maximum value. is the distinguishing or identification coefficient and is the pre-processed response value. If all the parameters are given equal preferences then, is taken as 0.5. The grey relational coefficient after finding the grey relational coefficient, the grey relational grade is computed by averaging the grey relational coefficient corresponding to each performance characteristics. The overall evaluation of the multiple performance characteristics is based on the grey relational grade, given by the equation [8][9]. ∑ (6) Where, is the grey relational grade for the jth experiment and k is the number of performance characteristics. The grey relational grade for each experiment using L18 orthogonal array is shown in the Response values Sequences of each performance characteristic after data processing MRR (gm./min) TWR (gm./min) SR (µm) MRR (gm./min) TWR (gm./min) SR (µm) Data pre-processing of the experimental result for each performance characteristics Multiple Objective Optimizations of Parameters in Rotary EDM of P20 Steel polarity Current (A) Pulse on time (µs) Pulse off time (µs) Tool rotation (RPM) The deviation sequences MRR (gm./min.) TWR (gm./min.) Surface roughness (µm) The deviation sequences The higher grey relational grade from the table indicates that the corresponding experimental result is closer to the ideally normalized value. From the table it is clear that among 18 experiments, experiment 12 has the highest grey relational grade. Therefore experiment 12 has the best multiple-performance characteristics. In this project optimization of the complicated multiple performance characteristics of rotary EDM of P20 die steel has been converted in to optimization of a grey relational grade. Since the experimental design is orthogonal, it is possible to separate out the effect of each machining parameter on the grey relational grade at different levels. For example, the mean of grey relational grade for the work piece polarity at levels 1, 2 and 3 could be found out by averaging the grey relational grade for the experiments 1 to 9 and 10 to 18 respectively. The mean of grey relational grade for each level of other machining parameters, namely, current, pulse on time, pulse off time and rotational speed of the electrode can be computed in the same manner. The mean of the grey relational grade for each level of machining parameters is summarized and shown in the multi response performance index. The total mean of the grey relational grade for the 18 experiments is calculated and listed in the the grey relational grade graph and the centre line indicated horizontally in figure 2 is the mean value of the grey relational grade. We know that when the grey relational grade increases, the multiple performance characteristics also become better [8][9][10][11]. The optimal combinations of the machining parameter can be determined more accurately only if the relative importance against the machining parameters. Grey relational grade graph. (Optimal setting from graph-(A2B1C1D2E2) Confirmation Experiment The improvement in the performance characteristics during the rotary EDM of P20 die steel can be verified using the confirmation test. The estimated grey relational grade using the optimal level of machining parameters can be calculated using the following equation.

V. Conclusions

The utilization of orthogonal array through grey relational analysis to optimize the rotary EDM process through multiple routine characteristics has been reported in this development. A grey relational analysis of the experimental consequences of the MRR, TWR and SR can convert optimization of multiple performances in to optimization of single performance characteristics called the Grey relational grade. Optimization of the complicated concert distinctiveness can be greatly simplified through this approach. It is exposed that the performance uniqueness of the EDM process such as MRR, TWR and

SR are better understanding by method proposed in this study.

References

[1]. Chow H M, Yan B H, Huang F Y: "Micro Slit Machining Using Electro-Discharge Machining with A Modified Rotary Disk Electrode (RDE)", Journal Of Materials Processing Technology, Vol.91, 1999, pp.161-166.

[2]. Aliakbari E, Baseri H: "Optimization of Machining Parameters in Rotary EDM Process by Using the Taguchi Method", International Journal of Advanced Manufacturing Technology, Vol.62, 2012, pp.1041-1053.

[3]. Bulent Ekmekci, Atakan Sayar: "Debris and Consequences in Micro Electric Discharge Machining Of Micro Holes", International Journal Of Machine Tools And Manufacture, Vol.65, 2013, pp.58-67.

[4]. Norlina Mohd Abbas, Darius G Solomon, Md. Fuad Bahari: "A Review on Current Research Trends In Electrical Discharge Machining (EDM)", International Journal of Machine Tool And Manufacture, Vol.47, 2007, pp.1214-1228.

[5]. Soni J S, Chakraverti G: "Machining Characteristics of Titanium with Rotary Electro Discharge Machining", Defence Science journal, Vol.171, (1/2), 1994, pp.51-58.

[6]. Soni J S, Chakraverti G: Performance Evaluation of Rotary EDM by Experimental Design Technique, Defence Science Journal, Vol. 47, No.1, 1997, pp.65-73.

[7]. Asai VD, Patel R I, Choudhary A B: "Optimization of Process Parameters of EDM Using ANOVA Method", International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol.3, No.2, April 2013, pp.1119-1125.

[8]. Narender Singh P, Raghukandan K, Pai B C: "Optimization by Grey Relational Analysis of EDM Parameters On Machining Al– 10%Sicp Composites, Journal Of Materials Processing Technology", Vol.155, 2004, pp.1658-1661.

[9]. Lin J L, Lin C L: "The Use Of The Orthogonal Array With Grey Relational Analysis To Optimize The Electrical Discharge Machining Process With Multiple Performance Characteristics", International Journal Of Machine Tools & Manufacture, Vol.42, 2002, Pp. 237-244.

[10]. Dr Chittaranjan Das v, Dr Srinivas C: "Optimization of Multiple Response Characteristics on EDM Using Taguchi Method and Grey Relational Analysis", ISSN: 2320-2491, Vol. 3, No. 2, April-May 2014, pp.19-30.

[11]. Raghuraman S, Thiruppathi K, Panneerselvam T, Santosh S: "Optimization Of EDM Parameters Using Taguchi Method And Grey Relational Analysis For Mild Steel IS 2026", International Journal Of Innovative Research In Science, Engineering And Technology, Vol.2, No.7, July 2013, pp.3095- 3014.