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OPTIMIZATION OF E.D.M PROCESS PARAMETERS USING TAGUCHI ALGO. AND MINITAB STATISTICAL SOFTWARE

A REVIEW AND CASE STUDY

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Abstract: In EDM various techniques can be applied to improve the material removal rate (MRR), surface roughness (SR) with different electrode combinations. However, the machining parameters are also effective while machining. In this study, an experiment is performed to analyze the effect of machining parameters viz. discharge current (Ip), pulse on time (Ton), voltage (v) over the responses of MRR and SR. For this Tungsten carbide tool or electrodes used while the work piece chosen as AISI 304 stainless steel. For the conduction of experiments, L9 orthogonal array is used to complete the runs. For analysis and explanations Minitab statistical software with Taguchi Equations is employed. Since optimum material removal rate is desired so higher the better criteria of Taguchi signal to noise ratio is employed for material removal rate. For surface roughness, lower the better criterion is advised. Through this study, not only the optimal settings for the MRR and SR is obtained but also the main parameters that affect the performance in EDM processes can also be found. The predicted optimal settings ensured maximum material removal rate and minimum surface roughness.

Keywords: Electrodes, Material removal rate, Surface roughness, Tungsten carbide, discharge current (Ip), pulse on time (Ton), voltage (v)

1.0 Introduction

Nowadays, modern industries are especially concerned with dimensional precision and surface finish. In order to obtain optimal cutting parameters, manufacturing to obtain optimal cutting parameters, manufacturing industries have depended on the use of handbook-based information which leads to decrease in productivity due to sub-optimal use of machining capability this causes high manufacturing cost and low product quality [1].

Hence, there is need for a systematic methodological approach by using Taguchi experimental methods and statistical/mathematical models. The design of experiments (DOE) is an efficient procedure for the purpose of planning experiments. Further the data can be analyzed to obtain valid and objective conclusions. Several experimental investigations have been carried out over the years in order to study the effect of cutting parameters on the work pieces surface integrity using several work pieces. Taguchi Method [2, 7] is developed by Dr.Genichi Taguchi, a Japanese quality management consultant. The method explores the concept of quadratic quality loss function and uses a statistical measure of performance called Signal-to-Noise (S/N) ratio. S/N ratio measure the quality characteristic deviation from the desired values. The term 'Signal' represents the desired value (i.e. mean) for the response and the term 'Noise' represents the undesired value (i.e. SD). Therefore, S/N ratio is the ratio of the mean to SD.

The following two types of S/N ratios are used in present case study:

1 Taguchi's S/N Ratio for (LB) Lower-the-better-

$SN_s = -10 \log (\sum y^2/n)$

2 Taguchi's S/N Ratio for (HB) Higher-the-better

$SN_L = -10 \log (\sum(1/y^2)/n)$

Electrical Discharge Machining is a most basic nontraditional machining process, where material is removed by thermal energy of spark occurring by means of repeated sequences of electrical ejections between the small gap of an electrode and a work piece. EDM is commonly used for machining of electrically conductive hard metals and alloys in automotive, aerospace and die making industries. EDM process is removing undesirable material in the form of debris and produce shape of the tool surface as of a metal portion by means of a recurring electrical ejection stuck between tool i.e. cathode and the work piece i.e. anode material in the existence of dielectric liquid. In this machining process work piece is called the anode because it is connected with positive terminal and electrode is connected with negative terminal i.e. called cathode. Dielectric fluid may be kerosene, transformer oil, distilled water, etc.

2.0 Literature Review

Some survey on research papers require to deliberate in this chapter connected towards Electrical Discharge Machining. From the readings out in these papers and thesis is mostly concerned through the EDM settings such as the discharge current, applied voltage, pulse on time, pulse off time, duty cycle, etc. and in what way these parameters will affect the machining outputs like MRR, Ra, TWR etc.

B. Sidda Reddy et al. [2] studied that influence by design four factors such as current, servo control, duty cycle and open circuit voltage over the outputs on MRR, TWR, SR and hardness on the die-sinker EDM of machining AISI 304 SS. They had been employed by the DOE technique with mixed level design and analysis for performing a minimum number of runs. They achieved that for higher MRR, the current, servo and duty cycle should be fixed as high levels and 95% confidence level with descending order in case of TWR with same factors.

M.M. Rahman et al. [3] experimentally found out the machining characteristic of austenitic stainless steel 304 through electric discharge machining. The investigation shows that with increasing current increases the MRR and surface roughness. The TWR increases with peak current until 150 µsec pulse on time. And from the results they were found for copper electrode all long pulse on time no tool wear with reverse polarity.

S. K. Dewangan [4] investigated the effect of machining parameter settings like pulse on time, discharge current and diameter of tool of AISI P20 tool steel material using U-shaped copper electrode with interior flushing technique. Experiments were conducted with the L18 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by which factor is most affected by the Responses of Material Removal Rate (MRR), overcut (OC) and Tool Wear Rate (TWR).

S. H. Tomadi et al. [5] analyzed the effect of machining settings of tungsten carbide on the outputs such as TWR, MRR and Surface finish. Confirmation test performed to evaluate error between predicted values and by experimental runs in terms of machining characteristics. They were found out copper tungsten tool use for better surface finishing of the work piece. They were using full factorial DOE for optimization and found out with greater pulse off time lesser tool wear of tungsten carbide and with current, voltage and pulse on time increment tool wear increased.

AKM Asif Iqbal and Ahsan Ali Khan [6] optimized the machining process parameters for the EDM milling operation of a stainless-steel work piece with copper tools. Input parameters are RPM of tool, feed rate and voltage while the outputs are MRR, TWR and Ra. Central composite design is utilized for optimization to get higher MRR, TWR and Ra. From the results the machining settings for optimal condition are done at 1200 RPM, voltage 120V and feed rate 4µm/Sec.

Norliana Mohd Abbas et al. [7] reviewed the trends of various research on EDM such as ultrasonic vibration assisted EDM, dry EDM, powder mixed EDM, water based EDM and various modeling techniques of EDM to precise and accurately EDM performance. They found that ultrasonic vibration assisted EDM is suited for micro machining, dry EDM is cost effective, water based EDM provides safe and conductive working environment, powder mixed EDM provides increasing surface quality, MRR and TWR.

Singh et al [8] investigated the influence of machining settings such as peak current on MRR, overcut, TWR and Ra in EDM of E31 tool steel heat treated with different tools such as copper, brass, aluminum and copper tungsten. From results copper and aluminum electrode gives higher MRR, overcut in diameter is minimum with this tools Sanjeev Kumar et al [9] reviewed on the new uses of electrical discharge machining (EDM) process, with certain prominence on the prospective of this process for surface alteration. Above and beyond removal of work material during machining, the fundamental nature of the process results in erosion of tool material also. Creation of the plasma passage containing of material vapors from the eroding work material and tool electrode; and pyrolysis of the dielectric affect the surface composition after machining and hence, its properties. Deliberate material transfer may be carried out under specific machining conditions by using either composite electrodes or by a breakup metallic powder in the dielectric or both. In this review on the wonder of surface modification by electric discharge machining and upcoming leanings of its applications.

B. Bhattacharyya et al. [10] Experimented on EDM using the development of a mathematical model based on RSM for correlating the interactive and higher order effect on machining parameter such as peak current and pulse on time of surface integrity of M2 Die steel machined through analysis of EDM parameters on surface roughness, white layer thickness and surface crack density. With the developed model the optimal combination evaluated for minimizing the surface integrity.

Dhar et al [11] developed a second order nonlinear mathematical model to establish the relationship between machining settings. And ANOVA has been performed to verify the fit and adequacy of the model. Process parameters on EDM are current, pulse on time and gap voltage over the responses of MRR, TWR and ROC of a composite material with brass tool having 30 mm cylindrical diameter.

I. Puertas et al. [12] Researched the consideration on the bite the dust sinking EDM with a sufficient choice of machining condition is the main parts of the machine. They were tracked down the effect of the highlights of power, beat on period and obligation cycle over established carbide or hard material like 94WC-6Co. They decide qualities: TWR, MRR and Ra by numerical recreations will be accomplished with the DOE strategy joined with numerous relapses has been adequately applied to demonstrating for ideal machining condition. At the point when force or heartbeat times were expanded, the unpleasantness esteem likewise expanded. Tungsten carbide low qualities ought to be utilized for both power and heartbeat time.

J. Simao et al [13] examined work on a superficial level alloying of the diverse work piece on machining over EDM. In tests powder metallurgy utilized powders suspended in dielectric fluid. In light of exploratory outcomes, the utilization of essential sintered cathodes produced using tungsten carbide brought about the arrangement of a uniform adjusted surface layer for certain miniature breaks and a normal thickness of up to 30 μm.

T. M. Chenthil Jegan et al [14] decides the arrangement of machining settings like pinnacle Current, Heartbeat on schedule, Heartbeat off time in EDM proposed for the machining of AISI202 hardened steel metal. They were utilizing of dark social examination method to streamlining the machining boundaries MRR and SR is presented. The best ostensible impact notwithstanding the request for meaning of the sensible impacts to the multi execution actual qualities on EDM machining strategy remained decided. The outcomes show that Release current was the principal boundary influencing the MRR.

S. Jai Hindus et al [15] done experimentations via the Crate Behniken plan. The impacts show that TWR and MRR are profoundly influenced utilizing Heartbeat on schedule and current (A). Chamber formed copper device guaranteeing a component of distance across of 13 mm is castoff to machining of tempered steel 316 L work piece. On MRR the most profound reason was discovered to be Heartbeat on time followed by top current (A) and the littlest huge was hole voltage. The MRR expanded directly with the increment in current (A). For apparatus wear the main factor was current (A) trailed by Heartbeat on schedule (tw) and furthermore horizontally with the expansion in voltage.

T. Rajmohan et al [16] tested utilizing plan of investigation procedure under L9 symmetrical cluster plan and

considering the impact of machining boundaries of EDM like heartbeat on schedule, beat off time , current and voltage on MRR in machining of AISI304 treated steel. For improvement they had been utilized sign to commotion proportion and investigation of fluctuation to dissect the impact of the boundaries on MRR and furthermore advance the cutting boundaries.

3.0 Plan Of Experiment

Orthogonal arrays are often employed in industrial experiments to study the effect of numerous control factors. An Orthogonal array is a type of experiment wherever the columns for the independent variables are orthogonal to one another. By orthogonal array
the analysis is simple and large saving in the experiment effort. By using an orthogonal array of standard procedure can be used for a number of experimental situations. To describe an orthogonal array [21], one must identify:

- Number of factors to be studied.
- Levels for each factor
- The specific two-factor interactions to be estimated.
- The special intricacy that would be encountered in running the experiment.

Table 1. Process Parameter With Their Values At Three Levels

LEVEL	LEVEL1	LEVEL2	LEVEL3
DISCHARGE CURRENT (Ip)	I1	I2	I3
PULSE ON TIME (Ton)	T1	T2	T3
VOLTAGE (V)	V1	V2	V3

In present investigation design of experiment was performed as L9 orthogonal array was chosen, which has 9 rows and 2 columns as shown:

Table 2. L9 Orthogonal Array in coded form

SR NO.	DISCHARGE CURRENT (Ip)	PULSE ON TIME (Ton)	VOLTAGE (V)
1	-1	-1	-1
2	-1	0	0
3	-1	1	1
4	0	-1	0
5	0	0	1
6	0	1	-1
7	1	-1	1
8	1	0	-1
9	1	1	0

4.0 Main Effects

The quality characteristics investigated in this study show that the combination of parameters and their levels make the best combination say optimal quality characteristic to be achieved. In this type the bigger is better to present the main effect graph.

The average effects of percentage of the material at level 1, 2, and 3respective values as average at the points are X1, X2, and X3. And the average values of levels at; L1, L2, L3 of given particle size: Y1, Y2, and Y3 as shown in Figure 1.

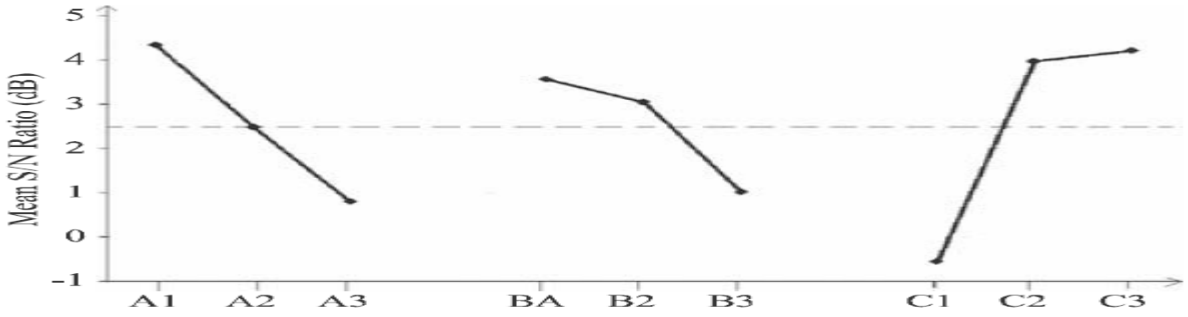

Fig 1 Mean S/N Ratio Graph

5.0 Conclusions

The Taguchi method is especially suitable for industrial use, but it can also be used for scientific research purposes, and it emphasizes a mean performance characteristic value close to the target.
value rather than a value within certain specified limits, thus improving the product quality. In present study, design of experiment is performed by L9 orthogonal array, chosen by considering three factors discharge current (Ip), pulse duration (Ton) and voltage (V) and three levels of each factor are employed to analyze the influence of process parameters by using main effects and analysis to get the optimal conditions and performances that means the best parameters within the experimental results. The discharge current taken in the present study is in the range 6-10 A, pulse duration (Ton) in range of 50-200 µs and voltage (V) in the range of 40-60 V as per literature review. Experimentations were varied to complete 9 altered trials and the weights of the work piece for calculation of MRR and with the help of profilometer surface roughness (Ra) have been measured. The optimum process parameters for material removal rate and surface roughness are calculated using Minitab statistical software. Finally, the optimum combinations of parameters are achieved by confirmation tests conducted to verify the results.

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