Optimization of Material Removal Rate in EDM Machining of OHNS Steel

Yogesh U. Sathe[1,] Pawan D. Somavanshi[2] , Sagar Kauthalkar[3]

[1]Assosiate professor, Mechanical Engineering, Government College of Engineering Aurangabad, Chhatrapati Sambhajinar

[2,3]Research scholar, Mechanical Engineering, Government College of Engineering Aurangabad, Chhatrapati Sambhajinar

Abstract - The experimental investigation of material removal rate during machining of OHNS steel using EDM machine was study in this paper. The input parameters include peak current, pulse on time, Pulse off time were used for experimental work S/N ratio graphs have been used to optimize the machining parameters of EDM on OHNS steel using the Taguchi method and ANOVA methods. The study will carry out to investigate the effect of which parameter has the largest effect on the material removal rate of OHNS steel by machining. The optimum machining condition for material removal rate (MRR) has been find out with the ANOVA analysis and regression equation.

This study is carried out by using the experimental investigation method and Taguchi analysis, at the end of this study we come to the conclusion of optimum conditions of the machining for OHNS material.

Key Words**:** S/N, ANOVA, MRR, Taguchi, EDM, OHNS.

1. INTRODUCTION

OHNS steel is a vital apparatus and kicks the bucket material, for the most part on account of its high quality, high hardness, and high wear obstruction. It has a high particular quality because of that it can't be effectively machinable by traditional machining strategies. EDM is a non-customary machining process that expels material by warm disintegration, for example, dissolving and vaporization of material. To comprehend the machining qualities of OHNS steel by EDM were investigated in this test think about. Pichai Janmanee et al. (2012) contemplated considers the impact of a copper-graphite anode material on tungsten carbide work pieces amid machining by EDM. The investigation found that by expanding the release current there was directed to the more material expulsion rate (MRR) and more anode wear proportion (EWR). Dilshad Ahmad Khan et al. (2011) talked about the impact of hardware extremity on the machining of silver steel by electric release machining. They presumed that immediate extremity is appropriate for higher MRR and lower relative EWR, yet turn around extremity gives better surface wrap up. N.Arunkumar et al. (2012) displayed the aftereffects of exploratory work did in EDM of EN31 utilizing three diverse instrument materials in particular copper, aluminum and EN24. They reasoned that copper experiences less instrument wear rate and high material evacuation rate.

Electrical Discharge Machining (EDM) is another customary machining process which is utilized to discover the change in beat voltage between a wire anode and a conductive work piece when instigated start disintegrates work piece material, evacuating material in such away is frequently invaluable where the work piece material is hard to be machined with a conventional machine device due its high quality hardness, sturdiness and so forth. Material is expelled from the work piece through restricted liquefying and vaporization of material. Electric sparkles are created between two cathodes when the terminals are held at a little separation from one another in a dielectric medium and a high potential distinction is connected crosswise over them. Confined districts of high temperatures are framed because of the sparkles happening between the two terminal surfaces. Work piece material in this limited zone softens and vaporizes. A large portion of the liquid and vaporized material is diverted from the interelectrode hole by the dielectric stream as flotsam and jetsam particles. After the material is evacuated because of a start, this hole increments and the area of the following sparkle movements to an alternate point on the work piece surface. The fitting feed movement of the instrument towards the work piece is by and large accommodated keeping up a consistent separation of hole between the apparatus and the work piece amid machining.

This is performed by either a servo engine control or stepper engine control of the apparatus holder. As material gets expelled from the work piece, the apparatus is moved descending towards the work piece to keep up a consistent between anode hole. Ordinarily in oil pass on sinking EDM, beat DC control supply is utilized where the apparatus is associated with the negative terminal and the work piece is associated with the positive terminal. Material evacuation rates of up to 300mm3/min can be accomplished amid EDM. The surface complete (Ra esteem) can be as high Irjet template sample paragraph Irjet template sample paragraph. as 50 µm amid harsh machining and even under 1 µm amid get done with machining. The volume of material evacuated per release is commonly in the scope of 10-6 - 10-4 mm3 and the material expulsion rate is more often than not somewhere in the range of 2 and 400 mm3/min relying upon particular application.

1.1 OBJECTIVE OF THE PRESENT WORK

- To study the effect of major parameters on Die sinking EDM response in machining OHNS O1 grade material.
- To develop the correlation between machining parameter performance measure higher material removal rate by using Taguchi Method for OHNS Steel material.
- To optimize machining performance in Die Sinking EDM of OHNS O1 grade Steel material.
- Investigation of the working ranges and levels of the EDM process parameters using one factor at a time approach
- Experimental determination of the effects of the various process parameters viz pulse on time, pulse off time, current on the performance measures MRR in EDM process
- Optimization of the performance measures using Taguchi method

2. LITERATURE REVIEW

Mehul Manoharan, Material Removal Rate, Tool Wear Rate and Surface Roughness Analysis of EDM Process, Electrical discharge machining (EDM) is one of the non-traditional machining processes, based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. The parametric analysis of the EDM process by using different electrode materials has been carried out. The Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR) is measured and recorded for detailed analysis. Different electrode. For high discharge current, copper electrodes show highest MRR, whereas Brass gives good surface finish and normal MRR. Since EDM is a thermal method, special attention must be paid to surface integrity. Surface and subsurface damage may be induced owing to thermal fatigue or to the material recast on the surface after removal. The MRR could be improved by carrying out research on electrode design, process parameters, EDM variations, powder mixed dielectric and electrically insulated electrodes. It is found that the basis of controlling and improving MRR mostly relies on empirical methods. This is largely due to stochastic nature of the sparkingphenomenon involving both electrical and non-electrical process parameters along with their complicated interrelationship.

Indhu Sekaran.N, Experimental Investigation and Optimization of Machining Parameters in Electrical Discharge Machining. This experimental aims at achieving the integrated approach to solve the optimization problem of EDM process. At any stage, the dominance factor of the input variables and output variables contained in the constraints and objective functions can be computed. Electric discharge machining is categorized as a thermoelectric process in which heat energy of spark is used to remove material from the work piece. The machining process involves controlled erosion of electrically conducting material by the initiation of rapid and repetitive electrical spark discharges between the tool and work piece separated by the dielectric medium. The present work is aimed at characterizing the electric discharge machining of HCHCR steels on EDM. Since an electrode with micro features is employed to cut its mirror image in the work piece, it is necessary to investigate the machining efficiency of the electrodes used. Furthermore, to improve the machining efficiency. The combination of gap voltage, Ampere setting were new line considered for maximum Material Removal Rate (MRR), Surface Roughness (SR), constrained circularity error and overcut. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of such as Ampere rating, sparking voltage while machining. In this study, the Taguchi technique and ANOVA were used to obtain optimal EDM parameters in the machining of HCHCR. The experimental results were evaluated using Taguchi technique. Optimal control factor and percentage of contribution were evaluated. Through this experimental finally we have found efficient machining optimum parameter for HCHCR material machining with graphite electrode.

Nibu Mathew, Study Of Tool Wear Rate Of Different Tool Aterials During Electric Discharge Machining Of H11 Steel At Reverse Polarity, In this paper an exertion has been made to analyze the handiness of cathode made through Powder Metallurgy (PM) in examination with customary copper terminal amid electric release machining. Exploratory outcomes are introduced on electric release machining of H11 steel in standard EDM oil with copper tungsten (75% Cu and 25%W) apparatus terminal made through powder metallurgy method and Copper cathode (99%Cu). A L18 (21 X 33) symmetrical cluster of Taguchi Methodology was utilized to distinguish the impact of process input parameters (viz. anode compose, top current, voltage and obligation cycle) on the yield factor (viz. Device wear rate). It was discovered that copper tungsten (CuW) improve through powder metallurgy gives TWR when contrasted with ordinary terminal (Cu) and the best parametric setting for least TWR is with CuW powder metallurgy instrument cathode, 4 ampere current, 40 volts hole voltage, 0.72 obligation cycle, i.e., A2B1C1D1.

Following ends can be drawn from the investigation of the outcomes. • From the trial results it was discovered that powder metallurgy instrument terminal (CuW) gives better TWR when contrasted with customary cathode. • TWR increments with the expansion in crest current, hole voltage and obligation cycle. • Best parametric setting for least TWR is with CuW powder metallurgy device terminal, 4 ampere current, 40 volts hole voltage, 0.72 obligation cycle. That is A2B1C1D1.

Kamaljit Singh Mahal, An Experimental Investigation: Machining of OHNS Steel by EDM, The exploratory examination of material expulsion rate, and smaller scale hardness amid machining of OHNS steel utilizing EDM machine was considered in this paper. The information parameters incorporate pinnacle current, beat on time; voltage hole and flushing weight were utilized for exploratory work. Mean impact plot and S/N proportion diagrams have been utilized to streamline the machining parameters of EDM on OHNS steel utilizing the Taguchi technique and ANOVA strategies. It very well may be seen that Current has the biggest impact on the material expulsion rate of OHNS steel by machining. It very well may be seen that flushing weight has the biggest impact on the hardness of OHNS steel by machining. The ideal machining condition for material expulsion rate (MRR) with positive extremity are Current (30 A), Pulse-on (100 µs) Voltage Gap (10 v) and flushing weight (20 lb/in2). The ideal machining condition for with positive extremity for hardness are, Current (10 amp.), Pulse-on (100 µs), voltage hole (20 volt) and flushing weight (10 lb/in2).

Following ends were made for ideal MRR and Hardness amid the machining of OHNS steel on EDM. 1. For OHNS steel ideal machining condition for material evacuation rate (MRR) amid machining on EDM were Current (30 A), Pulse on (100 µs), Voltage Gap (10 v) and flushing weight (20 lb/in2) with positive extremity. 2. For OHNS steel ideal machining condition for better hardness were, Current (10 amp.), Pulse-on (100 µs), voltage hole (20 volt) and flushing weight (10 lb/in2).

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3. METHODOLOGY

In the present study, experiments are designed on the basis of experimental design technique proposed by Box and Hunter (1957). The uniform-precision OHNS O1 grade Steel material has been used as the work piece material to improve the reliability of the results and to reduce the size of experiments without loss of accuracy. The strategy of complete randomization is adopted for conducting the experiments. On the basis of extensive preliminary investigations, literature and the experience of machine operators input parameters (control factors) are selected to develop empirical models for EDM in machining of OHNS O1 grade Steel material. Pulse on-time, pulse of-time & Current are selected as the input parameters. Table shows the levels and range of these parameters for the experiments as well as their codes

A scientific approach to plan the experiments is a necessity for efficient conduct of experiments. By the statistical design of experiments the process of planning the experiment is carried out, so that appropriate data will be collected and analyzed by statistical methods resulting in valid and objective conclusions. When the problem involves data that are subjected to experimental error, statistical methodology is the only objective approach to analysis. Thus, there are two aspects of an experimental problem: the design of the experiments and the statistical analysis of the data. Due to the potential difference between the wire and the work piece an electric field is setup across the spark gap, due to which this gap is broken down and flow of current starts. The heat generated in the gap results in melting, and finally vaporizing, the work piece material. In this way the material is removed from the work piece These two points are closely related since the method of analysis depends directly on the design of experiments employed

Standard L9 Orthogonal Array

It is a type of experiment wherever the columns for the independent variables are orthogonal to one another. By using an orthogonal array of standard procedure can be used for a number of experimental situations. To describe an orthogonal array, 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.

While there are many standard orthogonal matrices available, each of the matrices is intended for a specific number of variables and independent design levels.

The standard notation for orthogonal arrays is

Ln (Xm)

Where, n = Number of experiments to be carried out

X = Number of levels

m = Number of factors

Sr. No	Current	Pulse on Time	Pulse off Time
1	7	12	4
2	7	16	6
3	7	18	8
4	8	12	6
5	8	16	8
6	8	18	4
7	9	12	8
8	9	16	4
9	9	18	6

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4. PERFORMANCE ANALYSIS

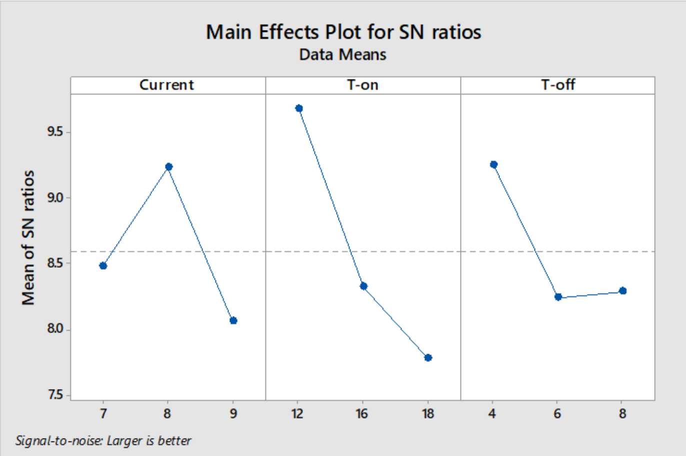
Model Analysis for MRR

L9 orthogonal array with repeat measurement of responses for runs one to nine. Repeats of response measurement technique is used overcome the drawback of saturated design in MINITAB software. It also shows that the SN ratio for run one and ten are same as it is calculated for the repeats measurement. The SN ratio values are calculated with help of MINITAB 17 software.

Sr No.	Current	Pulse on time	Pulse off time	MRR	S/N ratio
1	7	12	4	3.194	10.0867
2	7	16	6	2.471	7.8575
3	7	18	8	2.371	7.4986
4	8	12	6	3.201	10.1057
5	8	16	8	2.669	8.5270
6	8	18	4	2.841	9.0694
7	9	12	8	2.766	8.8370
8	9	16	4	2.689	8.5918
9	9	18	6	2.178	6.7612

Main Effects of MRR:

The influence of each control factor (pulse on time, pulse off time, and current) MRR was analyzed from the S/N ratio response table, which expresses the S/N ratio at each level of control factor. The control factor influence is determined by its level difference values. A bigger control factor level difference means a greater influence on the MRR Calculation of SN ratio:



A higher SN ratio with better characteristics was used and was calculated with the help of the MINITAB software for the experimental tests. The values of the complete SN ratio are SN ratio for the first test. From the graph, it is observed that the optimum material removal rate was in the lowest values of the in the response graph. The optimal input parameters were pulse on time 12 μsec (level 1), 8 A Current (level 2) and 4 s μsec pulse off time (level 1). The graph graphically shows the effect of the control factors on SS410 material. The configuration of the process parameters with the highest ratio always provides the optimum quality with a minimum variation. The graph shows the relationship change when the control factor configuration was changed from one level to another.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Current	2	0.197791	0.098895	21.38	0.045	20.75
T-on	2	0.567043	0.283521	61.30	0.016	59.51
T-off	2	0.178726	0.089363	19.32	0.049	18.76
Residual Error	2	0.009251	0.004625			
Total	8	0.952811				

The relevance of the models is tested by analysis of variance (ANOVA). It is a statistical tool for testing the null hypothesis for planned experiments, in which several different variables are studied simultaneously. ANOVA is used to quickly analyze the variances in the experiment using the Fisher test (F test). Table shows the result of the ANOVA analysis. The ANOVA analysis makes it possible to observe that the value of P is less than 0.05 in the three parametric sources. It is therefore clear that (1) the pulse on time, (2) the pulse off time, (3) the Current of the material have an influence on the SS410 steel material. The last column of cumulative anova shows the percentage of each factor in the total variance that indicates the degree of impact on the outcome.

Table shows the ANOVA of OHNS Steel & copper electrode. The table shows that the pulse on time (59.51%), the Current (20.75 %) and the pulse off time (18.76%) have a major influence on the MRR.

Multiple Linear Regression Models

To establish the correlations between the parameters are (1) pulse on time, (2) pulse off time, (3) Current, of OHNS Steel material the model of multiple linear regressions was obtained using the statistical software "MINITAB R 19". Terms that are statistically significant are included in the model. The final equation obtained is the following

MRR = 5.241 - 0.0672 (C/n) - 0.1002 (T-on) - 0.0765 (T-off)

Mathematical models of Current, pulse off time and pulse on time is calculated using MINITAB 19 software and analysis of regression carried out to obtain the predicted value of material removal rate.

Sr. No.	Experimental value	Predicted value	Error
1	3.194	3.262	2.08%
2	2.471	2.708	8.75%
3	2.371	2.354	2.72%
4	3.201	3.041	5.26%
5	2.669	2.488	7.72%
6	2.841	2.794	1.68%
7	2.766	2.821	1.94%
8	2.689	2.726	1.35%
9	2.178	2.373	8.21%

Shows the comparison of MRR results from the mathematical model developed in the present work with values obtained experimentally respectively. By comparing the results of values obtained from MRR equation and results of confirmation test, we have concluded that the confirmation test holds the equation for the values which are not included in the orthogonal array.

Confirmation experiment result

Parameter	Predicted Value	Experimental value	Error %
MRR	3.194	3.397	6.35

5. CONCLUSIONS

- This study covers the observations about the Material surface roughness over OHNS steel material by the process of EDM machine for the different input parameters to thoroughly study over the effect of EDM machining process. Throughout the experimentation we got some results as under,
- The optimal solution obtained for MRR based on the combination of EDM parameters and their levels is (i.e. Pulse on Time12 μsec at level 1, Current 8A at level 2 and Pulse off Time 4 μsec at level 1). The Pulse on Time and pulse on time are more significant Machining Parameters than Pulse off time and current.
- ANOVA results indicate that pulse on time plays prominent role in determining the MRR. The contribution of pulse on time, current and pulse off time to the quality characteristics MRR is 59.51%, 20.75% and 18.76% respectively.
- MRR increases with Pulse on Time and Current as higher will be the energy applied and spark there by generating more amount of heat energy during this period. MRR is directly proportional to the amount of energy applied during Ton. Higher the value of Ton, higher will be the energy produced and this will lead to the generation of more heat energy.
- The optimal cutting parameters are determined using Taguchi methods match with the experimental values by minimum errors i.e 6.35% for MRR.
- Through the developed mathematical models, any experimental results of MRR with any combination of EDM parameters can be estimated.

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