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Parametric Optimization for MRR on H-13 Die Tool Steel on EDM using Taguchi Techniques

Pardeep Narwal[1], Jai Singh[2]
[1]Post Graduate Student, Emax Institute of Engineering and Technology Ambala Haryana, INDIA
[2]Associate Professor, Emax Institute of Engineering and Technology Ambala Haryana, INDIA

ABSTRACT

The die tool steel is make H-13, it have widely applications in the Hot punches and dies for blanking, forging, swaging and bending, Nozzles for aluminum, tin and lead die casting, Hot extrusion dies for aluminum, cores, ejector pins, inserts, Hot shear blades etc. as the H-13 steel has widely applications so it is chosen for the present study. The works shows the effect of various process parameters like peak current, Pulse on Time, and Feed rate on Material Removal Rate using EDM Drilling. For the response variables Taguchi technique is used.

Keyword-- EDM drilling, Material Removal Rate, Peak current, Pulse on Time and Feed rate, H-13 Die tool steel, Taguchi technique

I. INTRODUCTION

A EDM Drilling machine was used as the experimental machine in this study. A Copper Tool with a diameter of 5 mm was used as an electrode to erode a work piece of H-13 Die Tool steel (flat plate). EDM is a non-traditional process based on removing unwanted material in the form of debris from a part by means of a series of recurring electrical discharges (created by electric pulse generators in micro seconds) between the work material in the presence of a dielectric fluid (kerosene, distilled water) and a tool called electrode and. EDM machining is an cost-effective and important method of machining hard and brittle electrically conductive materials. In EDM, since there is no direct contact between the electrode and the work piece, hence it can eliminate mechanical stresses chatter and vibration problems during machining. All type of conductive material can be machined using EDM irrespectively the hardness of the material. Both tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/de-ionized water is very common type of liquid dielectric medium.

II. LITREATURE REVIEW

Andad Pandey et. al. (2010) Present manufacturing industries are facing challenges from these advanced materials viz. super alloys, ceramics, and composites, that are hard and difficult to machine, requiring high precision, surface quality which increases machining cost. To meet these challenges, non-conventional machining processes are being employed to achieve higher metal removal rate, better surface finish and greater dimensional accuracy, with less tool wear. Electric Discharge Machining (EDM), a non-conventional process, has a wide applications in automotive, defense, aerospace and micro systems industries plays an excellent role in the development of least cost products with more reliable quality assurance. Die sinking EDM, Rotating pin electrode (RPE), Wire electrical discharge machining (WEDM), Micro- EDM, Dry EDM, Rotary disk electrode electrical discharge machining (RDE-EDM) are some of the variants methods of EDM. The present paper reviews the state of the art technology of high-performance machining of advanced materials using Die Sinking EDM, WEDM, micro-EDM, dry EDM.

Ashok Kumar et. al. (2014) In this paper, an attempt has been made to machining the En-19 tool steel by using U-shaped copper electrode performer on electrical discharge machine. Where Diameter of U-shaped electrode, Current and Pulse on time are taken as process input parameters and material removal rate, tool wear rate, Overcut on surface of work piece are taken as output parameters. A set of eighteen experiments (Taguchi design) were performed on electronic make smart ZNC electric discharge machine and relationships were developed between input and output parameters. The study indicates that, MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically. In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool. In the case of over cut the most important factor of discharge current then diameter of the tool and no effect on pulse on time.

Kuldeep Ojha et. al. (2011) Electrical discharge machining (EDM) is one of the earliest non-traditional machining processes. EDM process is based on thermoelectric energy between the work piece and an electrode. Material removal rate (MRR) is an important performance measure in EDM process. Since long, EDM researchers have explored a number of ways to improve and optimize the MRR including some unique experimental concepts that depart from the traditional EDM sparking phenomenon. Despite a range of different approaches, all the research work in this area shares the same objectives of achieving more efficient material removal coupled with a reduction in tool wear and improved surface quality. The paper reports research on EDM relating to improvement in MRR along with some insight into mechanism of material removal. In the end of the paper scope for future research work has been outlined.
Nikhil Kumar et. al. (2012) Electrical discharge machining (EDM) is one of the nontraditional 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 performance of the process, to a large extent, depends on the electrode material, work piece material manufacturing method of the electrodes. A suitable selection of electrode can reduce the cost of machining. So in this paper Die –Sinker EDM using copper and graphite electrode experiment has been done for optimizing performance parameters and reducing cost of manufacturing, finally it is found that a graphite electrode give better performance in certain characteristics but the cost become high for machining so keeping in mind cost and other some characteristics a graphite electrode is more suitable than copper electrode in case of both MRR and TWR.

Pichai Janmance et. al. (2011) When a depth hole is drilled by EDM, taper is occurred which is not desired in the process. This research was focused on influence of EDM parameters on material removal rate (MRR), electrode wear rate (EWR) and tapered hole of martens tic stainless steel AISI 431. The considered factors consist of electrical current, on-time, duty factor, and water pressure and servo rate. The experimental results reveal that MRR increases when increasing of servo rate. The taper of hole increases with increasing of electrical current and servo rate. However, it is reverse proportion to water pressure and duty factor.

Pravin R. Kubade et. al. (2012) This study investigates the influence of EDM parameters on EWR, MRR and ROC while machining of AISI D3 material. The parameters considered are pulse-on time (Ton), peak current (Ip), duty factor (t) and gap voltage (Vg). The experiments were performed on the die-sinking EDM machine fitted with a copper electrode. The experiments planned, conducted and analyzed using Taguchi method. It is found that the MRR is mainly influenced by (Ip); where as other factors have very less effect on material removal rate. Electrode wear rate is mainly influenced by peak current (Ip) and pulse on time (Ton), duty cycle (t) and gap voltage (Vg) has very less effect on electrode wear rate. Peak current (Ip) has the most influence on radial overcut then followed by duty cycle (t) and pulse on time (Ton) with almost very less influence by gap voltage (Vg).

III. EXPERIMENTATION

The experiments were conducted using the Electric Discharge Machine, model ELEKTRA PULSPS 53 the polarity of the work piece was set as negative while that of electrode was positive. The dielectric fluid used was EDM oil. Various input parameters varied during the experimentation are Pulse on time, Current and Feed rate. The effect of these parameters is studied on Material Removal Rate. Different settings of Pulse on Time, Pulse off Time, Current and flushing pressure were used in the experiments. The work piece material H-13 die tool steel was used. The chemical composition of H-13 die tool steel are given in Table 1

Material	Percentage %
Carbon	0.3132
Manganese %	0.2930
Phosphorus	0.8432
Sulphur	0.0235
Silicon	0.0139
Chromium	5.169
Vanadium	1.159
Moly	1.433
Remaining	Iron

Table -1 Chemical Composition of H-13 die tool steel

The results for various combinations of parameters were obtained by conducting the experiment as per the orthogonal array L9. The calculated results were analyzed using the commercial software MINITAB 16 specifically used for design of experiment applications and the graphs for various S/N (signal to noise) ratios and mean values for metal removing rate (MRR) were obtained by MINITAB R16.

To measure the quality characteristics, the experimental values are transformed into signal to noise ratio. The influence of control parameters such as current, pulse on time, and feed rate on metal removing rate (MRR) has been analyzed using signal to noise response table. The control factors are statistically significant in the signal to noise ratio.

Select the quality characteristics

There are three types of quality characteristics in the Taguchi methodology such as:

1. Smaller-the-better
2. Larger-the-better
3. Nominal-the-best

The goal of this research was to analyze and determine maximum MRR. Therefore, a larger the-better quality characteristic was implemented because MRR is desirable property of material and our objective is to maximum MRR of H-13 die tool steel.

Select noise factor and control factor

From the literature survey, we conclude that current, pulse on time, and feed rate had significant effect on metal removing rate (MRR). These are controllable input factors.

Table 2 shows all Taguchi design parameters and levels. One of the most important considerable attributes of Taguchi parameter design was S/N ratio.

Controllable factors	Ip	Ton	Feed Rate
Level 1	15	30	5
Level 2	25	40	7
Level 3	35	50	9

Table 2 Selected Factors and Levels Select orthogonal array

The selection of Orthogonal array depends on three items in order of priority, viz., the number of factors and their interactions, number of levels for the factors and the desired experimental resolution or cost limitations.

A total of nine experiments were performed based on the run order generated by the Taguchi model. The response for the model is metal removing rate (MRR).

In Orthogonal array, first column is assigned to current, second column is assigned to pulse on time and third column is assigned to feed rate and the remaining columns are assigned to their interactions and errors associated with them.

The objective of model is to maximize the metal removing rate (MRR). The Signal to Noise (S/N) ratio, which condenses the multiple data points within a trial, depends on the type of characteristic being evaluated.

The S/N ratio characteristics can be divided into three categories, viz. 'nominal is the best', 'larger the better' and 'smaller the better 'characteristics. In this study, 'larger the better' characteristics was chosen to analyze the For the present experimental work the three process parameters each at three levels have been decided. It is desirable to have three minimum levels of process parameters to reflect the true behavior of output parameters of study. MRR test was performed with three parameters: and varying them for three levels. According to the rule that degree of freedom for an orthogonal array should be greater than or equal to sum of those parameters, a L9 Orthogonal array. As per above parameters we select L9 orthogonal array (OA) in the Taguchi parameter design. The general layout of L9 orthogonal array is shown in Table 3.

Expt. No.	Column 1	Column 2	Column 3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 3 L9orthogonal array for experiment

IV. CONDUCT THE EXPERIMENTS

The work piece material used was H-13 die tool steel. These specimens were cut in the nine pieces by hacksaw. Metal removing rate (MRR) values were collected with the help of Edm machine. S/N ratio was calculated with the help of following Eq. (1).

$$S/N\ (\eta) = -10\log\frac{1}{n}\sum_{i=1}^{n} y_i^2$$

Where y1, y2...yi are the response of MRR;
and n is the number of observations.

The result of L9 orthogonal array is shown in table 5.3. The metal removing rate (MRR) of the work pieces obtained by the testing on EDM machine. Three responses were taken from each experiment e.g. R1, R2 and R3 responses for each experiment. The signal-to-noise ratio calculated for the output responses.

Fig. 1 EDM machine NIT KKR

Fig. 2 Work piece during working

Fig.3 Machined work piece and tool

For MRR, the signal-to-noise ratio should be large e.g. larger the S/N ratio, better will be the MRR.

The response table for signal to noise ratios shows the average of selected characteristics for each level of the factor. This table includes the ranks based on the delta statistics, which compares the relative value of the effects. S/N ratio is a response which consolidates repetitions and the effect of noise levels into one data point.

S N	Ip	Ton	F R	W_I (g)	W_f (g)	W_L (g)	T T (s)	MRR (mg/s)
1	15	30	5	24. 480	24. 180	0.31	359	0.84
2	15	40	7	24. 670	24. 350	0.32	365	0. 86
3	15	50	9	24. 540	24. 240	0.33	363	0. 88
4	25	30	7	24. 370	24. 010	0.30	349	0. 85
5	25	40	9	24. 510	24. 220	0.34	342	0.89
6	25	50	5	24. 680	24. 310	0.32	332	1.04
7	35	30	9	24. 540	24. 240	0.32	330	0.99
8	35	40	5	24. 870	24. 540	0.31	310	1.14
9	35	50	7	24. 370	24. 650	0.34	282	1.37

Table 4 Result of L_9 orthogonal array

Level	Ip	Ton	FR
1	-1.27778	-0.94651	-0.06710
2	-0.42406	-0.13560	0.64718
3	1.64243	1.23200	-0.44849
Delta	3.14921	2.14710	1.13887
Rank	1	2	3

Table 5 Response Table for Signal to Noise ratios-Larger is better

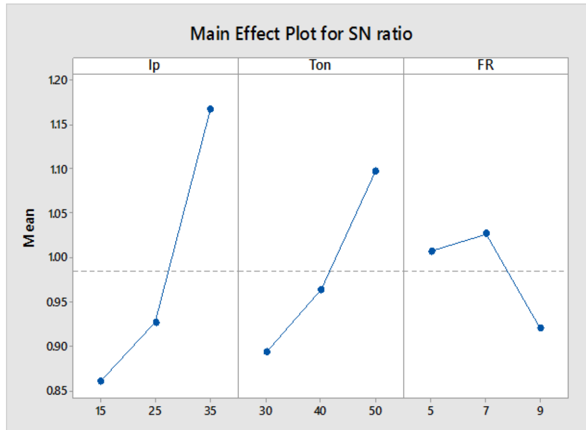

Fig.4 Main Effects Plot for SN ratios

Level	Ip	Ton	FR
1	0.8583	0.9000	1.0450
2	0.9613	0.9890	1.1367
3	1.2590	1.1867	0.9510
Delta	0.4117	0.2947	0.1814
Rank	1	2	3

Table 6 Response Table for Means- Larger is better

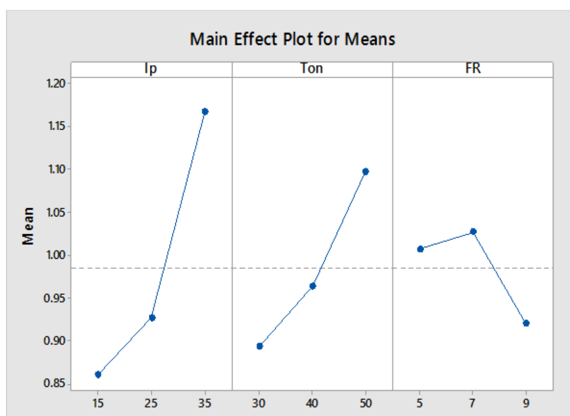

Fig.5 Main Effects Plot for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%
Current	2	14.756	15.756	7.8829	4.70	0.175	54.78
Pulse on time	2	7.134	7.268	3.6692	2.24	0.319	26.40
Feed rate	2	1.850	1.730	0.9751	0.58	0.645	7.75
Residual Error	2	3.272	3.232	1.4859			12.78
Total	8	29.186					

Table 6 Analysis of Variance- MRR

From this ANOVA table, we give the results that following parameters such as current [55.78%], Pulse on time[26.40%] and feed rate [7.75%] which are influencing metal removing rate(MRR). MRR is influenced by current, Pulse on time and feed rate respectively. We know that MRR which is volumetric loss of H-13 die tool steel is highly influenced by current.

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