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Effect of EDM Parameters in Obtaining Maximum MRR and Minimum EWR by Using Taguchi Method

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Abstract-It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat-treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.The objective of this research work is to investigate the effects of process variables like Gap Voltage (V), Pulse Current (A), Pulse Duration (μs), Pulse Off Time (μs) and Dielectric Pressure (kg/cm^2)on performance parameters such as EWR in the DM machining processThe Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time and diameter of tool of Monkel k-500 material. A well-designed experimental scheme was used to reduce the total number of experiments. Parts of the experiment 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 Electrode Wear Rate (EWR).

Keywords: EDM, EWR,ANOVA and Optimization

1. INTRODUCTION

Electrical discharge machining (EDM) has become the most popular, non- traditional, material removal process in today's manufacturing practice. This is due to a number of reasons. EDM enables one to machine extremely hard materials, and complex shapes can be produced with high precision. Its inherent capability for automation is another feature fulfilling the expectations of modern manufacturing. EDM is therefore mostly applied in the die and mold-making industry and in the construction of prototypes. The advent of numerically controlled equipment enabled various new EDM technologies such as deep sinking EDM along several axes, contouring EDM, wire EDM and milling EDM. This, together with a higher performance and better accuracy, yielded a functional expansion that is partially responsible for the growing interest in EDM. Within the above-mentioned industries, EDM is mostly applied to machine metals, such as high alloyed steels. One of the conditions required to make EDM feasible is electrical conductivity of the material

2. PRINCIPLE OF EDM

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig1. Both tool and work piece are submerged in a dielectric fluid/Kerosene/EDM oil/deionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases.

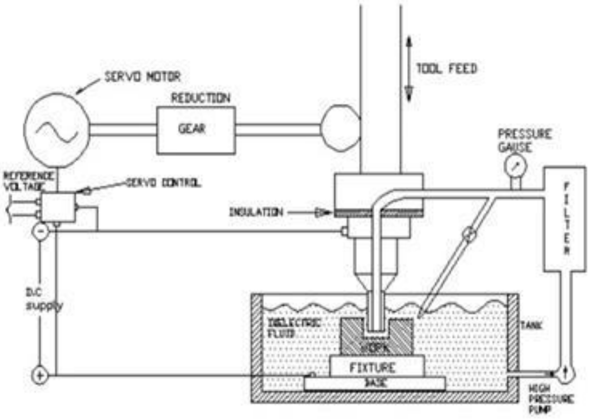

Fig 1Set up of Electric discharge machining

This Fig1 is shown the electric setup of the Electric discharge machining. The tool is mead cathode and work piece are anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark in interval of from 10 of micro seconds. And positive ions and electrons are accelerated, producing a discharge channel that becomes conductive. It is just at this point when the spark jumps causing collisions between ions and electrons and creating a channel of plasma. A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as a result of which a very high temperature is reached and at such high pressure and temperature that some metal is melted and eroded.

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3. Literature Review

Dhar and Purohit [1] evaluates the effect of current (c), pulse-on time (p) and air gap voltage (v) on MRR, TWR, ROC of EDM with **Al–4Cu–6Si alloy–10 wt. % SiC_P composites**. This experiment can be using the PS LEADER ZNC EDM machine and a cylindrical brass electrode of 30 mm diameter. And three factors, three levels full factorial design was using and analyzing the results. A second order, non-linear mathematical model has been developed for establishing the relationship among machining parameters. The significant of the models were checked using technique ANOVA and finding the MRR, TWR and ROC increase significant in a non-linear fashion with increase in current. **Karthikeyanet .al** [2] haspresented the mathematical molding of EDM with **aluminum-silicon carbide particulate composites**. Mathematical equation is *Y*=f(*V*, *I*, *T*). And the effect of MRR, TWR, SR with Process parameters taken in to consideration were the current (I), the pulse duration (T) and the percent volume fraction of SiC (25 µ size). A three level full factorial design was choosing. Finally the significant of the models were checked using the ANOVA. The MRR was found to decrease with an increase in the percent volume of SiC, whereas the TWR and the surface roughness increase with an increase in the volume of Sic. **Taweel**[3]. The central composite second-order rotatable design had been utilized to plan the experiments, and RSM was employed for developing experimental models. Composite electrode is found to be more sensitive to peak current and Pulse on time than conventional electrode. The multi response optimization result for maximum MRR and minimum TWR.

B.Mohanand Satyanarayana [4] evolution the of effect of the EDM Current, electrode marital polarity, pulse duration and rotation of electrode on metal removal rate, TWR, and SR, and the EDM of **Al-Sic with 20-25 vol. % SiC**, Polarity of the electrode and volume present of SiC, the MRR increased with increased in discharge current and specific current it decreased with increasing in pulse duration. Increasing the speed of the rotation electrode resulted in a positive effect with MRR, TWR and better SR than stationary. The electric motor can be used to rotate the electrode(tool) AV belt was used to transmit the power from the motor to the electrode Optimization parameters for EDM drilling were also developed to summarize the effect of machining characteristic such as MRR, TWR and SR.

Yan-Cherng et.al [5]. Experimental design was used to reduce the total number of experiments. Parts of the experiment 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 ANOVA and F -test. The relationship of MRR and SR with pulse duration graph in different peak current is as shown in Fig. 2.3. During the experiment MRR increases with peak current MRR initially increased to a peak at around 100 µs, and then fell. **J. Simao et al** [6] was developed the surface modification using by EDM, details are given of operations involving powder metallurgy (PM) tool electrodes and the use of powders suspended in the dielectric fluid, typically aluminum, nickel, titanium, etc. experimental results are presented on the surface alloying of **AISI H13** hot work tool steel during a die sink operation using partially sintered WC / Co electrodes operating in a hydrocarbon oil dielectric. An L8 fractional factorial Taguchi experiment was used to identify the effect of key operating factors on output measures (electrode wear, workpiece surface hardness, etc.). With respect to micro hardness, the percentage contribution ratios (PCR) for peak current, electrode polarity and pulse on time. Even so, the very low error PCR value (for micro hardness ~6%) implies that all the major effects were taken into account.

P. Narender Singh et al. [7]discuss theevolution of effect of the EDM current (*C*), Pulse ON-time (*P*) and flushing pressure (*F*) on MRR, TWR, taper (*T*), ROC, and surface roughness (SR) on machining as-cast **Al-MMC with 10% SiCp** . And use of metal matrix composites. ELEKTRAPULS spark erosion machine was used for the purpose and jet flushing of the dielectric fluid, kerosene, was employed. Brass tool of diameter 2.7mm was chosen to drill the specimens. An L27 OA, for the three machining parameters at three levels each, was opted to conduct the experiments. ANOVA was performed and the optimal levels for maximizing the responses were established. Scanning electron microscope (SEM) analysis was done to study the surface characteristics.

A. Soveja et al [8] have defined the experimental study of the surface laser texturing of **TA6V alloy**. The influence of the operating factors on the laser texturing process has been studied using two experimental approaches: Taguchi methodology and RSM. Empirical models have been developed. They allowed us to determine a correlation between process operating factors and performance indicators, such as surface roughness and MRR. Results analysis shows that the laser pulse energy and frequency are the most important operating factors. Mathematical models, that have been developed, can be used for the selection of operating factors' proper values in order to obtain the desired values of the objective functions.

BiingHwa et al. [9] has discuss the investigates the feasibility and optimization of a rotary EDM with ball burnishing for inspecting the machinability of **Al_2O_3/6061Al composite** using the Taguchi method. Three ZrO_2 balls attached as additional components behind the electrode tool offer immediate burnishing following EDM. Three observed values machining rate, surface roughness and improvement of surface roughness are adopted to verify the optimization of the machining technique. Design of tool electrode is Cupper ring shaped BEDM as shown in Fig 2.4. This B-EDM process approaches both a higher machining rate and a finer surface roughness. Furthermore, the B-EDM process can achieve an approximately constant machining rate.

Yan-Cherng Lin et al. [10]has reported that Electrical Discharge Energy on Machining of **Cemented Tungsten Carbide** using an electrolytic copper electrode. The machining parameters of EDM were varied to explore the effects of electrical discharge energy on the machining characteristics, such as MRR, EWR, and surface roughness. Moreover, the effects of the electrical discharge energy on heat-affected layers, surface cracks and machining debris were also determined. The experimental results show that the MRR increased with the density of the electrical discharge energy. The EWR and diameter of the machining debris were also related to the density of the electrical discharge energy. When the amount of electrical discharge energy was set to a high level, serious surface cracks on the machined surface of the cemented tungsten carbides caused by EDM were evident

3. EXPERIMENTATION WORK

Experimental Workpiece with Their Specification

Modern industry promotes the use of alternative advanced materials (composites, super alloys, and ceramics) for establishing design and manufacturing. Monel k-500that is precipitation hardenable, due to the additions of Aluminum is given as-

Table 1 Chemical Composition of Monel K-500

Element	Fe	C	Si	Mn	Cr
Concentration (weight %)	96.73	0.45	0.30	0.75-1.0	1.1

3.1 EDM-DRILL MACHINE

The experimental work was carried out with the help of special purpose EDM Drill machine (EDD 44) made by Sparkonix (India) Pvt. Ltd. Feed rate of consumable brass electrode was controlled and regulated with the help of automatic servomotor control mechanism of EDM drill machine. A special rotary head has been fabricated and attached to the quill of the EDM machine to provide rotary motion to the electrode. The electrode-rotating device consists of a precision spindle, a timer belt drive mechanism, and a speed control unit.

Fig2 EDM-Drill machine

4. DESIGN OF EXPERIMENT

Table 1 Control Parameters and their Levels

Control Parameters	Level 1	Level 2	Level 3
Gap Voltage (V)	50	60	-
Pulse Current (A)	8	10	12
Pulse Duration (μs)	6	8	10
Pulse Off Time (μs)	2	4	6
Dielectric Pressure (kg/cm^2)	80	90	100

OA is selected in such a way that DOF of OA should be greater than or equal to the sum of the DOF of control factors. L18 (2^1,3^4) mixed level OA is available for this combination where one control factor has two levels and remaining four control factor have 3 levels that was shown in Table 1.

Table 2 L18 Orthogonal Array

S. No.	Gap Voltage	Pulse Current	Pulse Duration	Pulse off Time	Dielectric Pressure
1	50	8	6	2	80
2	50	8	8	4	90
3	50	8	10	6	100
4	50	10	6	2	90
5	50	10	8	4	100
6	50	10	10	6	80
7	50	12	6	4	80
8	50	12	8	6	90
9	50	12	10	2	100
10	60	8	6	6	100
11	60	8	8	2	80
12	60	8	10	4	90
13	60	10	6	4	100
14	60	10	8	6	80
15	60	10	10	2	90
16	60	12	6	6	90
17	60	12	8	2	100
18	60	12	10	4	80

5 RESULTS AND DISCUSSION

Experimental results corresponding to individual and multi response optimization for Monel K-500 in this chapter. The plots between the control parameters and response parameters have been obtained using Minitab 16 software.

Variation of MRR with Control Parameters

Table 3 SNR Table of EWR

Control Parameter	Level-1	Level-2	Level-3
V	29.08*	24.77	-
I	27.88*	27.80	25.10
T_{ON}	26.89	26.66	27.23*
T_{OFF}	26.20	25.07	29.52*
P_D	24.39	24.93	31.46*

For EWR, SNR corresponding to gap voltage level-1 and level-2 was calculated by taking the mean of η_{MRR} of 1-9 and 10-18 experiment respectively.

Mean of SNR (smaller is better) for EWR is shown in Fig 3. SNR will decrease by 14.82% as gap voltage increases from 50V to 60V form level-1 to level-2. SN ratio also decreases by 0.28% and 9.71% when current increases from 8A to 10A and 10A to 12 A respectively in cases of level 1, 2 and 3 whereas in case of pulse duration initially it decreases by 0.85% and dramatically increases by 2.13% from level-1 to 2 and level 2 to 3 respectively.

The SN ratio will decrease in case of pulse offby4.31% from level-1 to level-2 and then increases by 17.75% from level-2 to level-3 while dielectric pressure increases by 2.21%, 26.77%, from level-1 to 2 and level-2 to 3 respectively.

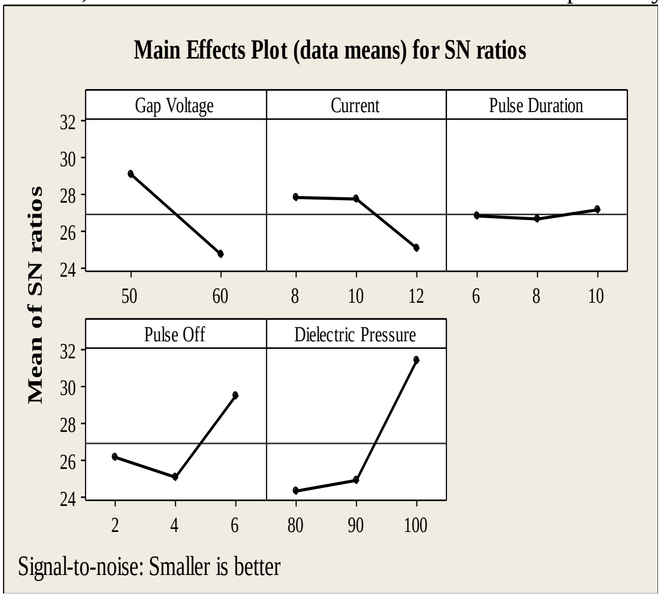

Fig. 3SNR plot for EWR

6 CONCLUSIONS

The objective of this work is to analysis the machining input parameters during electric-discharge machining of Monkel k-500. To complete this investigation; total 18 experiments are conducted according to Orthogonal Array (OA) L18 (2^1,3^4) mixed level. Taguchi's design of experiments has been employed for planning experimental design. The optimization of the EDM-drill process is concerned with minimizing EWR, that can be achieved simultaneously with a particular combination of control parameters setting.

The experimental result obtained can be used in industry in order to select the best suitable parameter combination to get the required quality characteristics of the product. Therefore, the present work successfully evaluated the feasibility of EDM process for Monel K-500.

EWR, are reduced by some amount respectively. Pulse current is the most significant parameter affecting the multi response, while dielectric pressure has little effect on multi-response. It was evident from the above study that optimization of complicated multiple performance characteristics can be simplified through this approach based on the basic underlying philosophy of Taguchi methodology.

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