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EXPERIMENTAL INVESTIGATION ON PROCESS PARAMETERS FOR MACHINABILITY OF INCONEL 718 USING ZNC EDM WITH TAGUCHI APPROACH

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ABSTRACT

To attain high accuracy in process of manufacturing one of the most important aspects that is take in to consideration by manufacturing industries. Electrical discharge machining (EDM) is accurately used for machining geometrically complex and hard material component that are difficult to machine such as heat resistant steels, carbides, ceramics, super alloy, composite and heat treated tool steels. In this research the effectiveness and optimization of process parameter is evaluated in term of material removable rate (MRR) of Inconel 718 material by using ZNC spark erosion machine. Taguchi method is used to calculate and investigate the effect of machining parameters on the response. The major response that used for this experimental study is material removable rate (MRR). The corresponding machining parameters are Peak current (I_P), Pulse on time (T_{ON}), Pulse off time (T_{OFF}) and gap voltage. Result of the experiment is calculated and analyzed by using analysis of variance (ANOVA). It is observed that pulse of time and pulse off time are more affecting factors on MRR. This analysis was proposed to select the optimal machining condition for use in confirmation test. The confirmation test evaluates percentage deviation between experimental and predicated result.

Keywords: *ZNC EDM, Machining, Cu Electrode, MRR, Taguchi, ANOVA.*

I. INTRODUCTION

Electrical discharge machining (EDM) is an electro thermal non traditional process of eroding material from electrically conductive material with a successive electric sparks. Material removal depends upon the electric discharge erosion effect that is produced by electric sparks between two electrodes. The electrodes are separated by a dielectric liquid and subjected to an electric voltage. EDM process is extensively used in the die and mould making industry to generate mould cavity and complex shape and also used in Industries such as aerospace, aeronautics.. Current, pulses on time, pulse of time, gap voltage, feed and flushing pressure are taken as input parameter.

Lajis *et al.* presented relations between EDM Process parameters. Tungsten carbide and graphite electrode are taken for experiment. They considered peak current, voltage, pulse on time and pulse off time as input parameter. Investigated material removal rate (MRR) and roughness is largely affect by pulse on time [1].

Dewangen *et al.* process parameters like pulse on time, discharge current and diameter of electrode are studied and affect is investigated on material removal rate (MRR), over cut and tool wear rate (TWR). For this experiment work piece as AISI P20 tool steel and U shaped copper tool as electrode are taken. SN ratio is applied for optimizing the TWR and MRR. experiments were conducted for optimize the process parameters by Taguchi method. They find that the most influencing parameter was pulse on time for material removal rate and after that discharge current and diameter of tool [2].

Mohan *et al.* studied the effect of process parameters and their effect like voltage, pulse on time, current and pulse off time on material removal rate. For experiment work piece selected as stainless steel (304). They find that two important significant factors that affect the material removal rate (MRR) are pulse current and pulse on time [3].

Sahoo *et al.* find the effect of process parameters such as discharge current, pulse on time and duty cycle on material removal rate (MRR) and electrode wear rate (EWR). Electrode as copper with tungsten carbide in a die sinking

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EDM is used for Experiments. Response surface methodology used for optimization. They investigated most important factor that effecting on both MRR and EWR is peak current. Found that maximum MRR was achieved at 10A discharge current, 50µs pulse on time and 8 duty cycle and minimum EWR was achieved at 6A discharge current, 10µs pulse on time and 8 duty cycle [4].

Singh *et. al.* analyzed the effect of process parameters like pulse on-time and pulse-off-time for responses Metal removal rate (MRR) and Tool Wear Ratio (TWR). For this experiment they selected work piece as steel and electrode of copper material. They investigated that tool wear rate is decreased in copper electrode as pulse on time is increase and also decreased in Material removal rate as value of pulse on time is increased. [5].

Hocheng *et al.* study on the material removal rate of SiC/Al in electrical-discharge machining with relationship of electrical current and pulse on time and investigated the crater size produced by a single spark for material SiC/Al is large than steel and minimum crater is obtained by large current and pulse on time [6].

Liu *et al.* using micro-EDM they studied the effect on suitability of fabricating high nickel alloy and found micro-holes were successfully fabricated in high nickel alloy [7].

Liu *et al.* studied effect on micro-EDM combined with High-Frequency Dither Grinding (HFDG). They analyzed that rough surface of micro holes improve and reducing from 2.12 µm to 0.85 µm without micro cracks [8].

II. EXPERIMENTATION

The aim of this research is to calculate the effect of the machining variables like, Peak current, pulse on time, pulse off time and gap voltage on out coming performance such as MRR Inconel 718 as work piece as well as copper tool as electrode are taken for conducting experiment. Inconel 718 is an Nickel based super alloy with Nickel as the primary alloying element. It is very hard, electrical conductive material which is difficult to machine. It has low thermal expension propertie, high toughness, high work hardening rate and also highly abrasive carbide particles due to this it has strong tendency to weld. It is stronger in strength compare to many steels, good fatigue strength and average machinability.

The experiment is conducted with L9 orthogonal array by using Taguchi approach. For experiment all experiments are performed at machining conditions as shown in table 1 on Sparkonix Electrical Discharge machining set up as shown in figure 2.2. Four important factor and their levels are taken for conducting experiment as shown in table 2. For accuracy each experiment is repeated three times. Difference in weight basis method is used to compute Material Removal Rate (MRR) as shown in equation 1. Machining parameters, experimental results are optimize and analyzed by using MINITAB 15.0

MRR = *Wbm-Wam/ t* g/min …….. (I)

Wbm = Work piece weight before machining.
Wam = Work piece weight after machining.
t = Machining time (min)

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Figure 2.1: Work piece of Inconel 718 after machining with Cu electrode

Table 1.Experimental conditions

Description	Specifications
Work piece	Inconel 718
Electrode	Copper dia.12 mm and length 100 mm
Dielectric Fluid	EDM oil
Dielectric Pressure	1.0 Kgf/cm^2 with side flushing
Electrode Polarity	Positive

Table 2.Process parameters and their levels

MACHINING PARAMETER	SYMBOL	UNIT	LEVELS		
			1	2	3
Peak current	I_p	A	6	9	12
Pulse on time	T_{ON}	µs	30	60	90
Pulse off time	T_{OFF}	µs	15	45	90
Gap voltage	V	V	40	50	60

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Fig 2.2 Sparkonix ZNC EDM machine

III. RESULT AND DISCUSSION

Signal to noise ratio related to experimental values were determined and investigated which factor is most affected material removal rate (MRR), shown in table 3.1.Further from machining of Inconel 718 with copper tool the effects of machining parameters, i.e. peak current, pulse on time, pulse off time and gap voltage on material removal rate as obtained and observed the significance of process parameter in machining.

A. Influences on MRR

In experiment of EDM the effect of various machining parameter like pulse of time, pulse on time, peak current and voltage has moderate effect on MRR as shown in Table 3.2. Taguchi method is employed to analyze the result for response MRR from experiment on the basis of "larger is better" criteria. It is flagrant from the main effects plot of Fig. 3.2 indicates at 12 A peak current, 90 µs pulse on time, 15 µs pulse off time and voltage of 40 V voltages respectively gives highest MRR on these input parameters. DOE model developed to find the statistical validity of parameters on ANOVA analysis shown in Table 3.1. It is observed from experiment that the significance of the model and percentage contribution of Pulse on time (TON) is about 41.7 % which states the impact of pulse on time on material removal rate in EDM process as shown in Table 3.2.. It is analyzed that the impact on material removal rate of the parameters such as pulse off time (TOFF), current (Ip) and gap voltage (V) has less comparing Pulse on time (TON) .

B. Confirmatory Experimental Results

From optimum setting of EDM process parameters Confirmatory experiment was performed. The improvement in performance characteristics i.e. increase in MRR was observed from the confirmatory experiments. The validity of optimized work ensures from conformity experiment and the observation finds that within 29.16% deviation from the predicted values which is shown in table 3.4.

Table 3.1 DOE with experimental results for MRR

Run no.	Peak current (A)	Pulse on time (µs)	Pulse off time (µs)	Gap voltage (V)	MRR1 (g/min)	MRR2 (g/min)	MRR3 (g/min)	Mean MRR	S/N Ratio
1	6	30	15	40	0.051	0.056	0.052	0.053	-25.5145
2	6	60	45	50	0.048	0.064	0.033	0.048	-26.3752
3	6	90	90	60	0.035	0.032	0.034	0.033	-29.6297
4	9	30	45	60	0.027	0.025	0.025	0.025	-32.0412
5	9	60	90	40	0.053	0.093	0.058	0.068	-23.3498
6	9	90	15	50	0.187	0.203	0.202	0.197	-14.1107
7	12	30	90	50	0.025	0.025	0.026	0.025	-32.0412
8	12	60	15	60	0.180	0.178	0.196	0.184	-14.7036
9	12	90	45	40	0.214	0.225	0.224	0.221	-13.1122

Table 3.2 ANOVA of S/N ratios for MRR

Source	Degree of freedom	Sum of Squares	Mean Squares	F	Contribution
Peak current	2	78.523	39.261	1.35	16.7
Pulse on time	2	195.892	97.946	3.39	41.7
Pulse off Time	2	157.763	78.881	2.73	33.7
Gap voltage	2	37.047	18.524	0.64	7.8
Total	8	469.225			
Error	4	115.57	28.8925		

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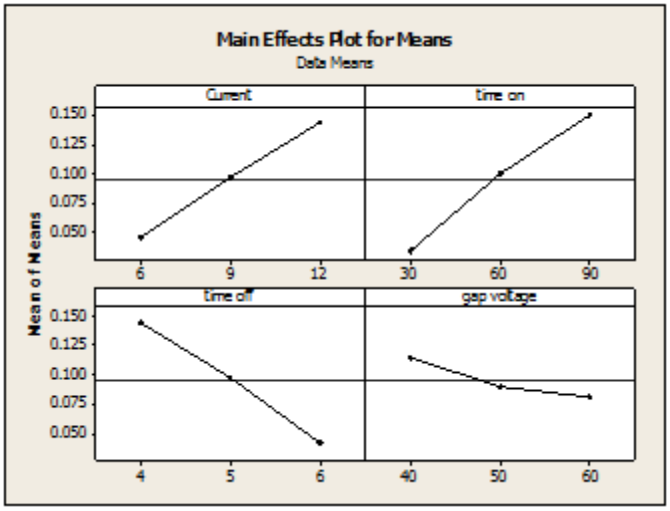

Fig 3.1 Mean plot of MRR (g/min)

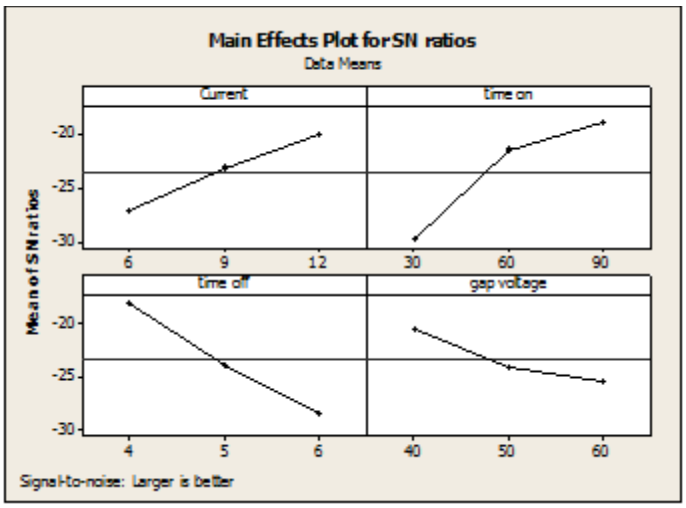

Fig 3.2 Mean plot for S/N Ratio (MRR)

Table 3.3 Optimal value for MRR

Parameter	Peak current	Pulse on time	Pulse off time	Gap voltage
MRR	12	90	15	40

Table 3.4 Percentage deviation for MRR

Output parameter	Predicted	Experimental	Percentage deviation
MRR(g/m)	0.221	0.312	29.16%

IV. CONCLUSION

In this research, impact of input factors on MRR of Inconel 718 has been investigated by EDM process. L9 orthogonal array related to Taguchi approach used for DOE. Result and response are conducted experimentally. Material removal rate in machining of the Inconel 718 concluded as follows:

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- Finding the result of MRR, Pulse on time is most affecting factor and after that pulse off time, current and gap voltage.MRR increased linearly with some extent of Pulse on time.

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