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OPTIMISATION OF PROCESS PARAMETERS FOR INCONEL 718 IN EDM

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ABSTRACT
The electrical discharge machining (EDM) is one of the most common and most accepted nontraditional machining processes used. It is an electro-thermal process and is based on erosion effect of electric spark on work piece and electrode .It is an erosion process due to thermal effect where metal removal takes place by a series of recurring electrical discharges between a cutting tool acting as an electrode and a conductive work piece the in presence of a dielectric fluid. This discharge occurs in a voltage gap between the electrode and work piece. The work piece material selected in this experiment is 3-Phase carbon fiber composite taking in to account its wide usage in industrial application. The discovery of carbon nanotubes (CNTs) of exceptional mechanical properties combined with low density has led to their novel use as reinforcing nano filler in composite materials. The high strength and stiffness of CNTs leads to improve tensile shear and flexural properties of multiscale composite. The effectiveness of 3-Phase carbon fiber reinforcement can be proven by the fact that even smaller amounts (<5wt%) of loading of CNTs resultant significant improvements in their mechanical and physical properties . The variable parameters are peak current, Pulse on time, gap voltage and Pulse off time. On the basis of PUGH matrix and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methodologies for FOUR FACTORS with THREE LEVELS of each factor, we have selected L9

ARRAY for DOE (Design of Experiments) to be carried out for knowing the TWR and MRR the effect of the variable parameters mentioned above upon machining characteristics such as MRR and TWR is studied and investigated. The tool material is Copper Cadmium.

Keywords- *Inconel 718, EDM, Copper Cadmium.*

INTRODUCTION
Electrical Discharge Machine (EDM) has now become the most important accepted technologies in manufacturing industries since many complex 3D shapes can be machined using a simple shaped tool electrode. EDM is an important 'non-traditional manufacturing method', developed in the late 1940s and has been accepted worldwide as a standard processing manufacture of forming tools that produce, die castings, plastic molding forging dies etc. New developments in the field of material science have led to new engineering metallic materials, composite materials , that have good thermal characteristics and mechanical properties as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Now a days, EDM is technique widely used in industry perform high precision machining of all types of electrically conductive materials such as: metals, metallic alloys, graphite, or even some ceramic materials as it has the ability to machine any material irrespective of its mechanical strength EDM technology is increasingly being used in tool, die and mould making industries, to machine the heat treated steels and some advanced materials (ceramics, super alloys and metal matrix composites) requiring high precision, complex shapes and high surface finish as it has no direct physical contact between the electrodes so that no mechanical stress is exerted on the work piece. Traditional machining technique is often based on removing material using tool material that is harder than the work material and is also unable economical machining. An EDM is based on the eroding effect of an electric spark on both the electrodes used. EDM is actually a process in which we utilize the removal phenomenon of electrical-discharge in dielectric. Therefore, the electrode plays an important role, which affects the material removal rate (MRR) and the tool wear rate (TWR) which are the main output parameters of EDM. Since EDM was developed, much theoretical and experimental work has been done to identify the basic processes involved.

MATERIALS AND METHODS
Taguchi Method, Inconel 718

EXPERIMENTAL SETUP:

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EDM Machine Specifications

The following are the specifications of the EDM machine used during the experimentation:

Model	ZNC 50 A
Make	Sparkonix, PUNE
Value	Rs. 32,12,406.00
Maximum Work Piece Size	800*500*325(mm*mm*mm)
Maximum Work Piece Weight	300 Kg.
Main Table Traverse	550*350(mm*mm)
Resolution	0.0005 mm
Peak Current Range	1 to 20 ampere
Gap Voltage Range	10 to 120 volts
Pulse Duration Range	0.2 to 500 µ-seconds
Dielectric Fluid	Kerosene
Tank Capacity	170 Lt.
Cooling System	2000 K-Cal.
Connected Load	10 KVA
Total Heat Generated	10 K-Cal/Hour
Temperature to be maintained	20+/- 2oC
X Travel	300 mm
Y Travel	200 mm
Z Travel	200 mm

Properties of Dielectric Fluid

The dielectric used during machining was KEROSENE which has following properties:

Dielectric Strength	14 to 22 MV/m
Dynamic Viscosity	1.64 g/m-sec.
Thermal conductivity	0.149 W/m-K
Specific Heat Capacity	2.16 J/g-K

Properties of Work Piece Material

The work piece material used in the experiment is Inconel 718 which has a very high strength to weight ratio and is suitable for the application in the following fields:

Rocket Industry
Nuclear Power Plants
Gas Turbines

The properties of Inconel 718 are as follows:

Carbon fibre	718
Density	8.19gm/cc
Hardness	39 HRC
Weight	409gm (in 100*100*5 mm3 sample)
Size of Sample	100*100*5 mm3

Workpiece

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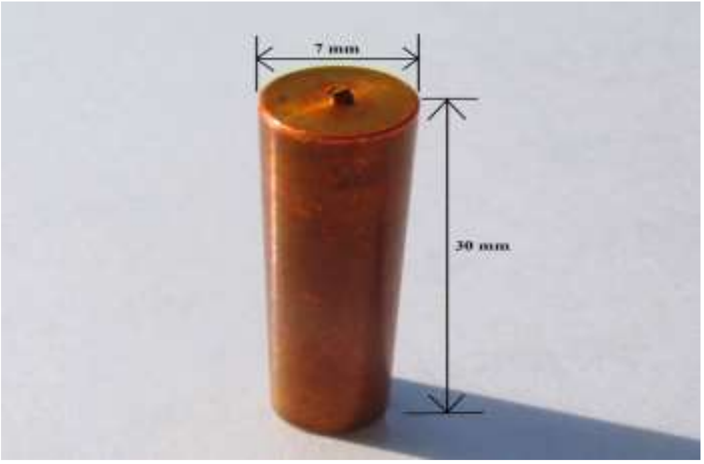
Properties of Tool Material

The tool used in the experiment is of COPPER-CADMIUM which is widely being used in industries for tooling of EDM. The properties of copper cadmium are as follows:

Thermal Conductivity	391 W/m-oK
Melting Point	1083 oC
Electrical Resistivity	1.69 ohm- cm
Specific Heat Capacity	0.385 J/gm-oC
Size of Sample	8 mm (Ø) * 30mm



Tool

Experiment Procedure

During the experimentation process following procedure has been followed:

a) Selection of various parameters whose effect we want to know.
b) DESIGN OF EXPERIMENT (DOE) for deciding the combination of various selected factor for the various experiments to be carried out
c) Selection of level values of various selected factors.
d) Checking the dimensions of tool & work piece.
e) Measurement of the weight of tool & work piece.
f) Performance of machining operation with the 9 set of tool & work piece alternatively on EDM machine for 9 experiments and with the appropriate setting of various selected parameters as decided by the DOE.
g) Again measurement of weight of tool & work piece after machining.
h) Mathematical analysis of data obtained

Experimental setup for machining

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Selection of Factors

On the basis of study of various papers and articles about EDM process, we have come to know that the following factors have reasonable effect on material removal rate during EDM machining process:

1. PEAK CURRENT(Ip)
2. GAP VOLTAGE(Vg)
3. PULSE ON TIME(Ton)

DESIGN OF EXPERIMENTS (DOE)

On the basis of TAGUCHI method for THREE FACTORS with THREE LEVELS of each factor, we have selected the L9 ARRAY for DOE of the experiments to be carried out for knowing the MRR. The table for L9 array is as followed.

Selection of Level Values

On the basis of study of various papers on EDM machining of carbon fiber material, from the range of acceptable values of various selected factors, we have chosen the following suitable level values of selected factors

Table 1Various level values of selected factors

Factor Symbol	Process parameters	Units	Level 1	Level 2	Level 3
A	Peak current(Ip)	Ampere	8	12	16
B	Gap voltage (Vg)	Volts	50	55	60
C	Pulse-on-time (Ton)	Micro-seconds	75	100	150

Revised L9 Array Table for Experiment

By putting the selected level values of various selected factors from table 3.1 to table 3.2, we will get following L9 array table for actual experiment

Table 2 L9 array table for actual experiment

EXP.NO.	PULSE ON TIME (IN µ-SEC.) (TON)	PEAK CURRENT (IN AMP.) (Ip)	GAP VOLTAGE(Vg) (IN VOLTS)
1.	75	8	50
2.	75	12	55
3.	75	16	60
4.	100	8	55
5.	100	12	60
6.	100	16	50
7.	150	8	60

8.	150	12	50
9.	150	16	55

We have performed the 9-experiments on the basis of the above table on the various combination of factors as shown in the table 3.3 and after that we have measured the weight of tool & work piece and prepared the following table which shows the weight of tool & work piece before & after machining process;

RESULTS AND DISCUSSION

Material Removal Rate (MRR)

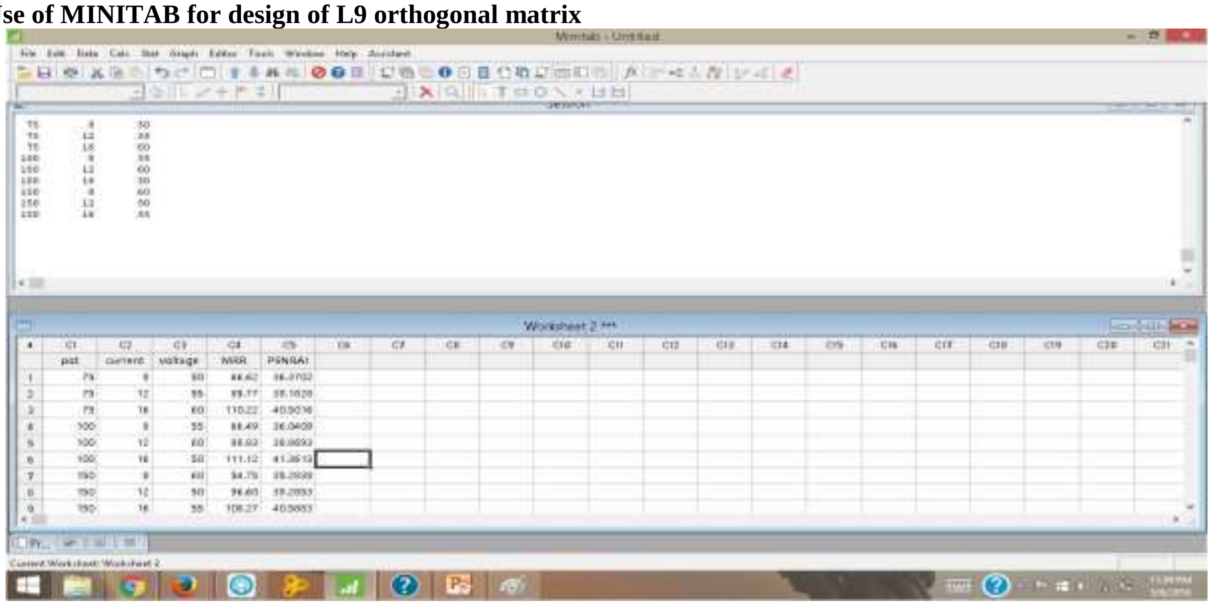
The material removal rate can be calculated from the following given relation [6];

$$\mathrm{MRR} = \frac{\mathrm{Weightreductionofworkpieceaftermachining}}{\mathrm{Timetakeninmachining}}$$

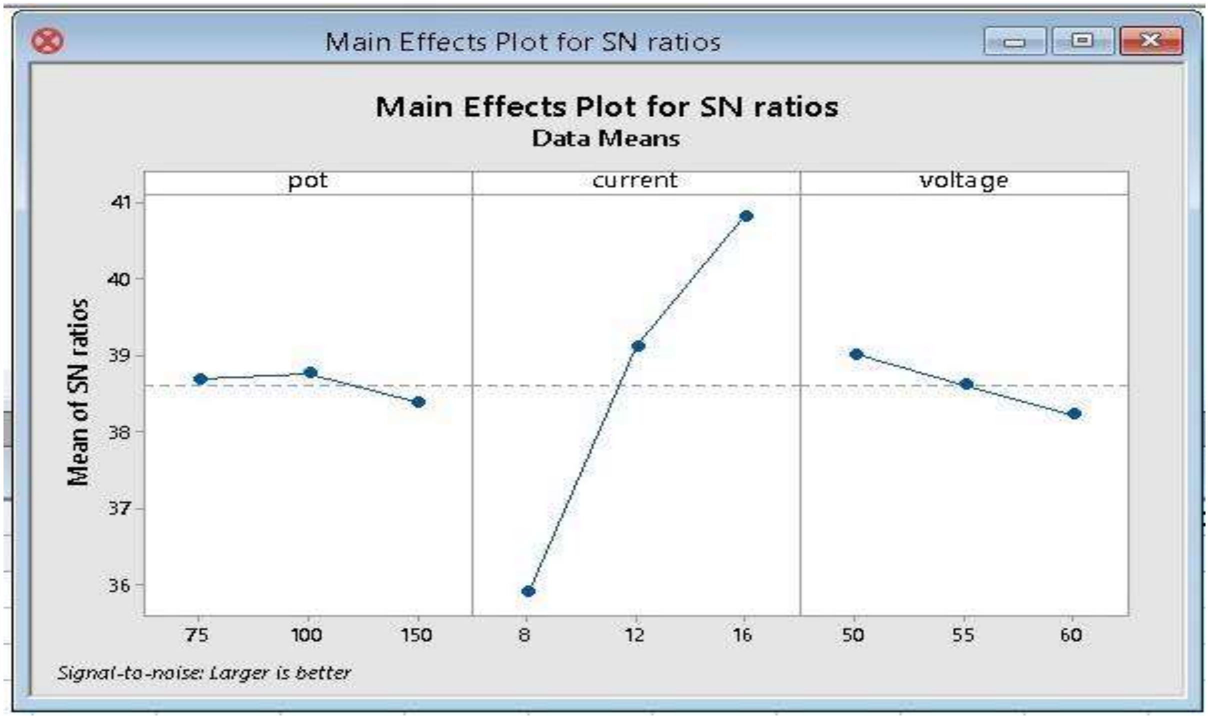
Table 3 Observation Table for MRR

Exp.no.	Weight before machining (in gram)	Weight after machining (in gram)	Material Removed (in gram)	Time Of Exp. (in minutes)	MRR (gm/minute)
1	409.00	407.00	1.998	30	0.0667
2	407.00	404.42	2.573	30	0.0857
3	404.42	401.11	3.306	30	0.1102
4	401.11	399.11	1.994	30	0.0664
5	399.11	396.44	2.664	30	0.0888
6	396.44	393.10	3.334	30	0.111
7	393.10	391.45	1.64	30	0.0547
8	391.45	388.55	2.898	30	0.0966
9	388.55	385.3	3.248	30	0.1082

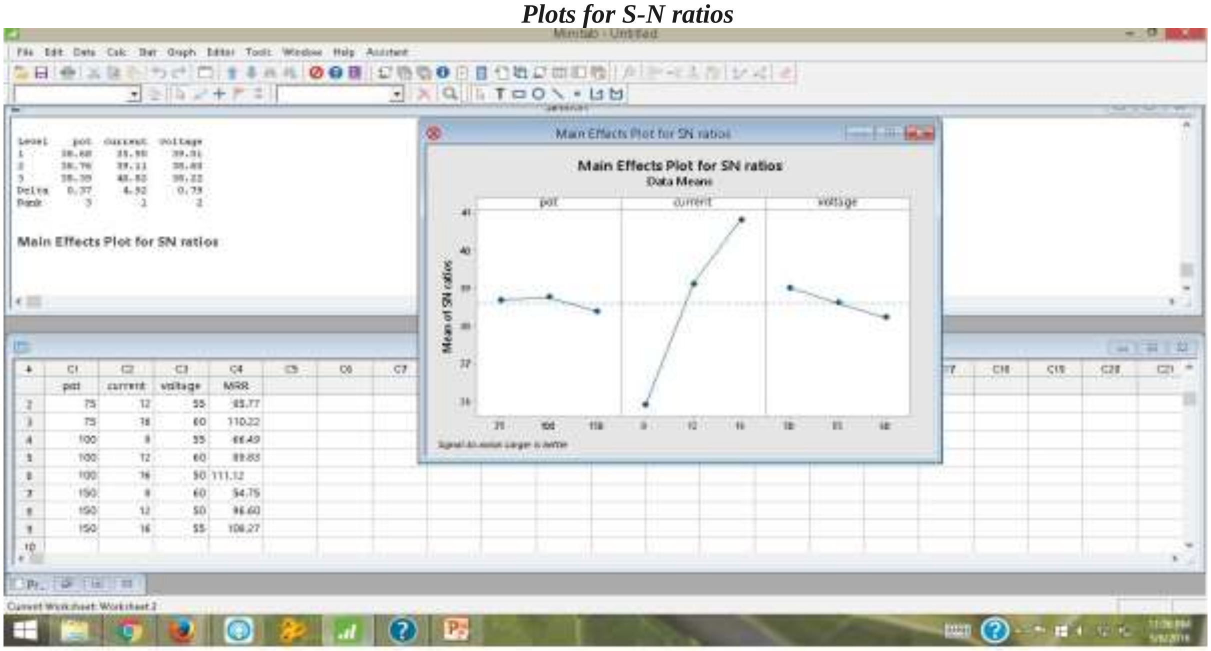
Use of MINITAB for design of L9 orthogonal matrix



Design of experiment



Plots for S-N ratios



Optimised values

CONCLUSION

Optimum Set of Parameters

The initial set of machining parameters at which the MRR is maximum obtained by TAGUCHI method is

PEAK CURRENT (Ip) -- LEVEL 3
GAP VOLTAGE (Vg) -- LEVEL 1
PULSE ON TIME (Ton) -- LEVEL 2

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Table 4 Optimal combination of process parameters with optimal value of MRR

Ip(Amp)	Vg (Volts)	Ton (μs)	MRR (gm/min.)
16	50	100	0.1111

After performing the confirmation test, the optimum set of parameters at which the MRR will be maximum is as follows;

Table 5 Optimal combination of process parameters with optimal value of MRR and TWR

Ip(Amp)	Vg (Volts)	Ton (μs)	MRR (gm/min.)
16	50	100	0.1111

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