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SOME STUDIES ON INVESTIGATING THE CONCEPT OF PERFORMING EXPERIMENTALLY EDM PROCESS PARAMETERS THROUGHOUT THE MACHINING OF HIGH CARBON HIGH CHROMIUM D2 TOOL STEEL THROUGH A TAGUCHI ORTHOGONAL ARRAY APPROACH.

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ABSTRACT

This study presents analysis of different parameters of EDM. In this work four parameters Current, Voltage, Pulse Off time and Pulse On time are varied. L9 orthogonal array is used. MRR and surface roughness are calculated after experiments. F test is applied and plots for MRR, TWR and SR are constructed. In this study the tool comes out factor which has maximum effect on all three outputs. The current comes out to be second most important factor. Value of current is directly proportional to MRR, TWR and SR. The work pieces are mainly significant in Surface roughness.

***Keywords*: EDM, MRR, Surface Roughness & TWR**

I INTRODUCTION

Electrical discharge machining (EDM) is a thermal process with a complex metal-removal mechanism, involving the formation of a plasma channel between the tool and work piece [1]. It has proved especially valuable in the machining of super-tough, electrically conductive materials such as the new space-age alloys that are difficult to machine by conventional methods [2]. The word unconventional is used in sense that the metal like tungsten, hardened stainless steel tantalum, some high strength steel alloys etc. are such that they can't be machined by conventional method but require some special technique . The conventional methods in spite of recent advancements are inadequate to machine such materials from stand point of economic Production [3]. In EDM process there are large number of parameters which affect MRR and TWR. A number of input process parameters can be varied in the EDM process. Each parameter has its own impact on output parameters such as material.

Important Parameters of EDM are written as follows:

a. Spark on-time (Ton): The duration of time (µs) the current is allowed to flow per cycle.

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b. Spark off-time (Toff): The duration of time in between the sparks generated. During this time the molten material gets removed from the gap between the electrode and the workpiece.

c. Voltage (V): It is the potential difference applied between the electrode and the workpiece.

d. Discharge Current (Ip): It is the current flowing through the electrode and is measured in amp.

e. Duty cycle (τ): It is the ratio of Ton divided by total cycle time (Ton+Toff).

f. Tool: It is act as an electrode and produce mirror image on the workpiece.

II LITERATURE REVIEW

A. Adan. [4] Investigated both conventional and non-conventional machining process to machining the Al 6061 MMC. Result showed that the surface roughness quality and hardness of material is directly affected by the machining process and it also overripe the microstructure of material, it was concluded that non-conventional techniques are effectively used where no microstructure changed.

V. Balasubramanium et al. [1] conducted an experimental work on EDM at different parameters to determine the optimization and performance of AL MMC (Aluminum metal matrix composite). Response surface methodology was used to prepare the experiments sheet. They observed the responses (MRR, TWR, SR and CY) are directly affected by varying the process parameters (peak current, T-on, flushing pressure & particles sizes) and notified that the mathematical models give a better result for our responses parameters.

C. Velmurugan et al. [3] investigated the impact of process variables (T-on, Current, Voltage and flushing pressure) of EDM in the appearance of responses such as MRR, TWR and SR during the machining of AL MMC which reinforced by particles of silicon carbide (10%) and graphite(4%). They calculated the significant effect and performances in the terms of responses with respect to process variable.

J.K Pushpendra et al. [5] reported the superior mechanical properties of AL MMC in comparison to other metals and materials. They studied the effect of machining of AL MMC during conventional and non-conventional machining process. They observed the irregular reinforcement make a material non-homogeneous and anisotropic in nature but by genuine compositions we make it better both as technically and economically.

D.Shravani.et al. [6] analyzed Taguchi L9 orthogonal array technique. To examine the outcomes of process parameters at their different levels the Taguchi experimental design was stipulated. They observed that Taguchi engaged at least no of trails from the actual no of combinations, in trails the parameters are arranged at their different levels within a way to optimize the result.

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III MATERIAL AND METHOD

3.1 Material

In this experimental work a high carbon high chromium D2 Tool Steel material is used which consist of Carbon varying from 1.55 to 1.75%, Manganese varying from .20 to 0.40%, Silicon varying from 0.25 to 0.40%, Molybdenum varying from 0.50 to 0.70%, Chromium varying from 11 to 12%, Vanadium varying from 0.10 to 0.50% and Tungsten varying from 0.40 to 0.60%.These steels retain their hardness up to a temperature of 425 °C (797 °F). Common applications for these tool steels include forging dies, die-casting die blocks, and drawing dies. Due to their high chromium content, certain high carbon high chromium-type tool steels are often considered stainless or semi-stainless, however their corrosion resistance is very limited due to the precipitation of the majority of their chromium and carbon constituents as carbides. It is very wear resistant but not as tough as lower alloyed steels. The mechanical properties of high carbon high chromium are very sensitive to heat treatment. It is widely used for the production of shear blades, planer blades and industrial cutting tools; sometimes used for knife blades. The physical and mechanical properties of high carbon high chromium steel is under:-

Physical properties	**Metric**	**Imperial**
Density	7.7 x 1000 kg/m3	0.278 lb/in3
Melting point	1421°C	2590°F

Mechanical Properties	**Metric**	**Imperial**
Hardness, Knoop (converted from Rockwell C hardness)	769	769
Hardness, Rockwell C	62	62
Hardness, Vickers	748	748
Izod impact unnotched	77.0 J	56.8 ft-lb
Poisson's ratio	0.27-0.30	0.27-0.30
Elastic modulus	190-210 GPa	27557-30457 ksi

3.2 Method

In this experimental study we suggest the four different factors (process parameters) up to their three levels. Table.1shown the proposed machine process parameters and their levels .

Table.1: Machining parameters and their levels.

Parameters	Units	Level 1	Level 2	Level 3
Current	A	8	10	12
Voltage	V	6	8	10
Pulse-on time	µs	10	20	30
Pulse-off time	µs	20	45	60

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Figure.1: Electric Discharge Machine Setup

This experimental work was carried out on Oscar Max EDM machine (Taiwan made) shown in Figure.. The specifications of EDM machine are shown in Table.2. In this experimental work the EDM oil is used as the dielectric fluid (specific gravity – 0.763) in which both work piece and tool are immersed and it also sprinkled between the gap of work piece and tool. A fabricated Aluminum based metal matrix composite (AL 6061+8%Sic+3%graphite) is used as a work piece and a copper rod of 12mm (Ø) is used as an electrode.

Table.2: Specification of EDM.

Pulse-on time	2-1800 µs
Pulse-off time	2-1000 µs
Current	0-120 amp
Voltage	1-16 V
Table size	1000 mm (L), 600 mm (W)
Tank size	1500 mm (L), 940 mm(w), 520 mm (H)
Outside dimensions	1720 mm (L), 1800 mm (W), 2610 mm (H)
Max. electrode weight	250 Kg
Max. work piece weight	2000 Kg

Response variables are the response parameters which give the performance of the machine and they are affected with the input parameters. Design variables selected for the experimentation were:

(i) MRR (Material Removal Rate)

(ii) SR (Surface Roughness)

Evaluation of MRR

MRR is the difference between weight of work piece (before and after machining) to the machining time.

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MRR (mg/sec) = $\frac{Wbm - Wam}{Mt}$

Wbm = weight of work piece before machining (gm)

Wam = weight of work piece after machining (gm)

Mt = total time of machining of each trail (sec)

Figure.2: Weighing Machine Image

Evaluation of SR

The surface roughness of the work-piece was expressed in arithmetic average (R_a). R_a is the arithmetic average roughness of the deviations of the roughness profile from the central line of the measurement. In this work, the surface roughness was calculated by Precise surface roughness tester.

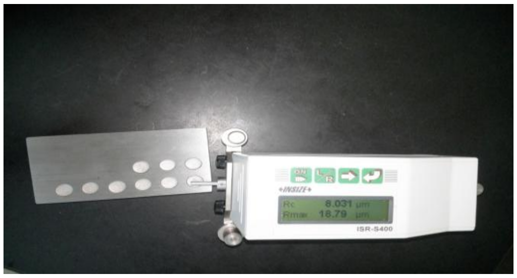

Figure.3: Surface Roughness tester image

The nine experiments which are performed they were designed into Taguchi orthogonal array L9 by using Design expert 9.0.6 software. These nine experiments display the combinations between process parameters at where we calculated our responses (MRR and SR) which are necessary to improve the productivity and quality.

IV TAGUCHI ORTHOGONAL ARRAY L9 (3^4)

Taguchi is one of the types of factorial design. In this design different no of factors and their levels are available. The taguchi make our design more flexible with less complexibility. In this paper we use orthogonal array L9 to make a design from the data. In L9 there are four parameters which have further their 3 levels. A regression

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expression is constructed in design expert 9.0.6 by using the experimental data. The regression model is represented as $Y = f(P_{on}, P_{off}, V, C)$

This expression represents the relationship between the response (dependent) variable and parameters (independent) variables. Here "Y" is represented our required response and "f" is represented the function of process parameters. By using orthogonal array L9 (3^4) the design sheet for experimental work shown in Table.4.2.

Table.3: Design sheet with responses.

RUN	CURRENT(A)	VOLTAGE	T-ON (µs)	T-OFF (µs)	MRR	SR
1	12	6	30	45	1.75	3.5
2	10	8	30	20	1.68	3.96
3	12	10	20	20	1.55	4.61
4	8	10	30	60	1.59	4.2
5	10	10	10	45	1.38	4.44
6	10	6	20	60	1.33	3.73
7	12	8	10	60	1.24	3.98
8	8	6	10	20	1.21	3.48
9	8	8	20	45	1.36	4.49

V MATHEMATICAL MODELS

The mathematical models disclose the effect of parameters on our desire response. At here it proves that the pulse-on time give a significant effect on responses (MRR and SR) as compared to other parameters.

5.1: Material Removal Rate

An empirical relationship between the response and the independent variables has been expressed by the following quadratic model Adsorption:

MRR = +1.45 -0.18 * C [1] -0.041* C [2]

$R^2 = 0.8082$

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Analysis of variance has been calculated to analyze the accessibility of the model. The analysis of variance for the response has been encapsulated in Table.4.

Table.4: ANOVA-Analysis of Variance

ANOVA for selected factorial model						
Analysis of variance table [Classical sum of squares - Type II]						
	Sum of		**Mean**	**F**	**p-value**	
Source	**Squares**	**Df**	**Square**	**Value**	**Prob > F**	
Model	0.24	2	0.12	12.64	0.0071	Significant
C-on	*0.24*	*2*	*0.12*	*12.64*	*0.0071*	
Residual	0.058	6	9.633E-003			
Cor Total	0.30	8				

Std. Dev.	0.098	R-Squared	0.8082
Mean	1.45	AdjR-Squared	0.7443
C.V. %	6.75	PredR-Squared	0.5685
PRESS	0.13	Adeq Precision	7.000

Now again to confirm the credibility of developed sample, in “minitab17” we draw the following 3-D graphs to examine that which process parameter mostly affected our response variable (MRR).

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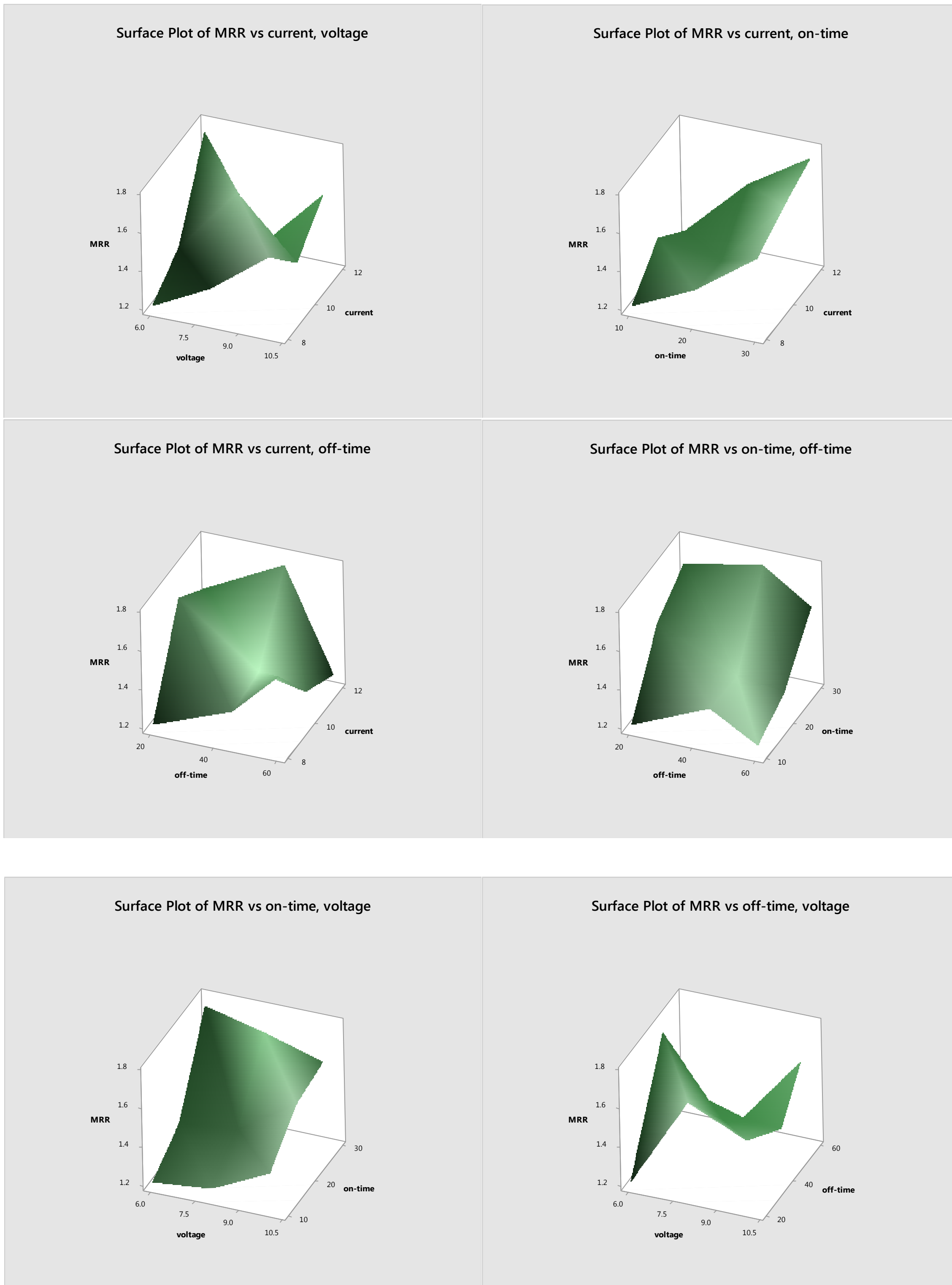

From these 3-D model graphs it confirmed that the “Pulse-on time” and “Current” both has the main two parameters which affect our response MRR directly.

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5.1.1 Confirmatory Test

For further support of optimized data which is analyzed under optimum parametric values, the confirmatory test is applied which results are shown as under. The both confirmatory test and calculated results are shown in Table.5.

Table.5: shows the confirmatory results and calculated results

Predicted solutions							
Number	on time	off time	voltage	Current	MRR	Desirability	
1	30	20	6	8	1.693	0.858	Selected
Experimental results							
Number	on time	off time	voltage	Current	MRR	Desirability	
1	30	20	8	10	1.68	0.808	

5.2: Surface Roughness

An empirical relationship between the response and the independent variables has been expressed by the following quadratic model Adsorption:

SR = +4.04 -0.47 * B[1] +0.10 * B[2]

$R^2 = 0.7866$

Analysis of variance has been calculated to analyze the accessibility of the model. The analysis of variance for the response has been encapsulated in Table.6.

Table.6: ANOVA-Analysis of Variance

ANOVA for selected factorial model						
Analysis of variance table [Classical sum of squares - Type II]						
	Sum of		**Mean**	**F**	**p-value**	
Source	**Squares**	**Df**	**Square**	**Value**	**Prob > F**	
Model	1.12	2	0.56	11.06	0.0097	Significant
B-V	*1.12*	*2*	*0.56*	*11.06*	*0.0097*	

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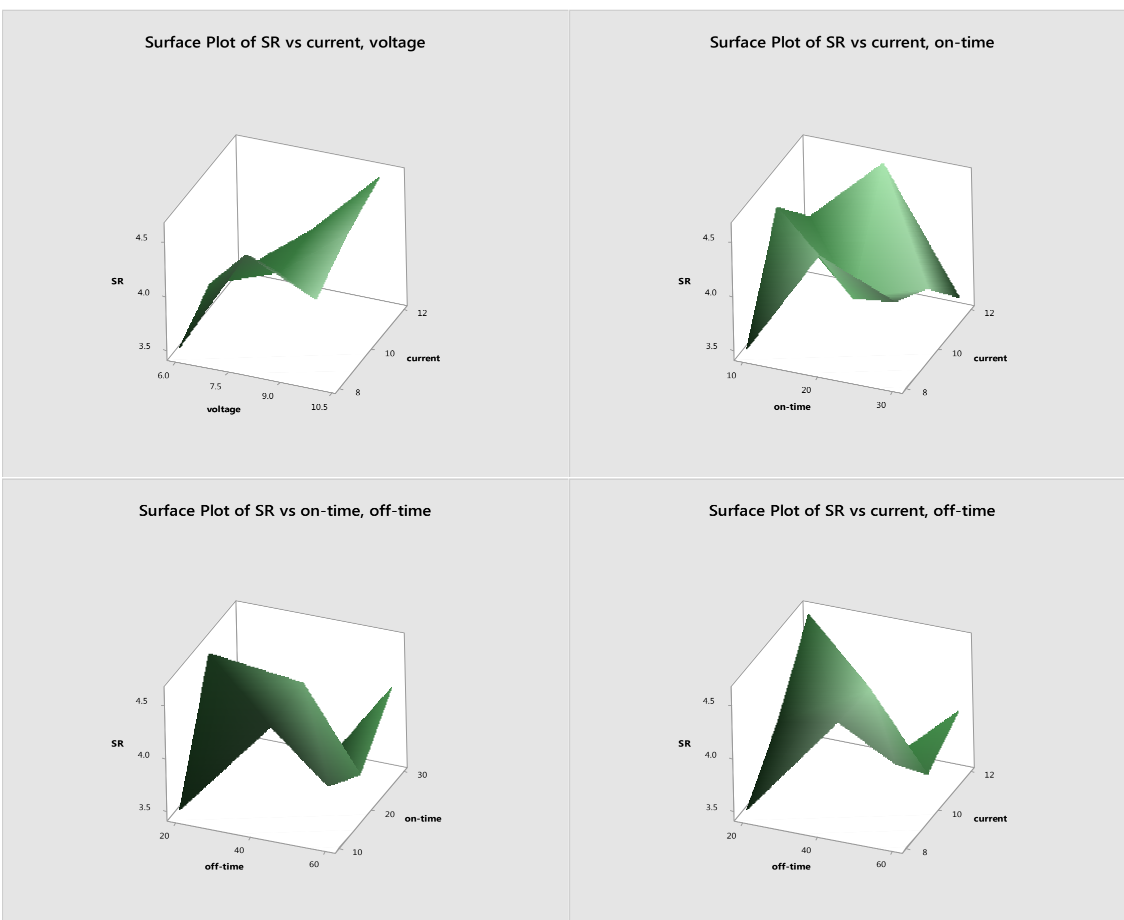
Residual	0.30	6	0.051			
Cor Total	1.42	8				

Std. Dev.	0.23	R-Squared	0.7866
Mean	4.04	Adj R-Squared	0.7155
C.V. %	5.57	Pred R-Squared	0.5198
PRESS	0.68	Adeq Precision	6.516

Now again to confirm the credibility of developed sample, in "minitab17" we draw the following 3-D graphs to examine that which process parameter mostly affected our response variable (SR).



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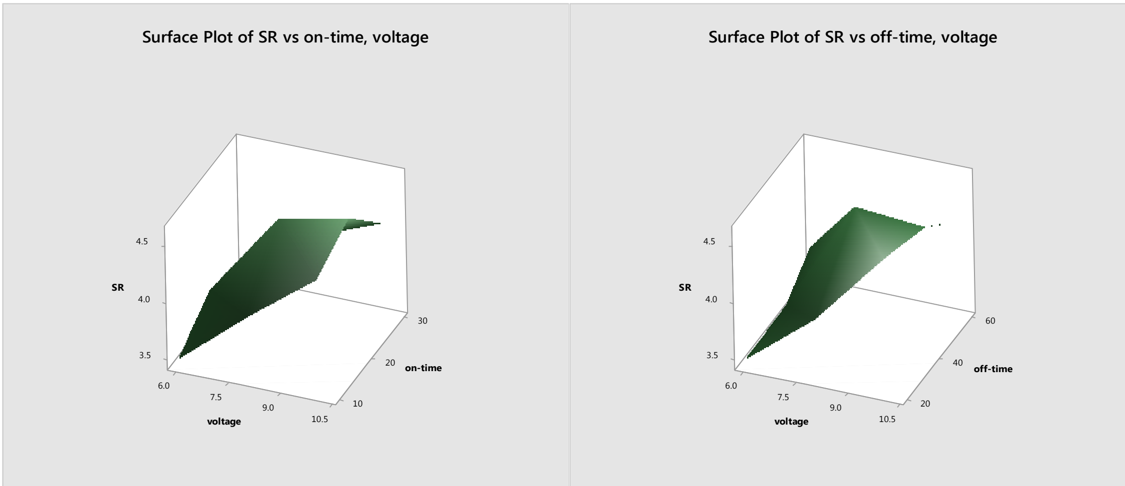

From these 3-D model graphs it confirmed that the "Pulse-on time" and "Current" both has the main two parameters which affect our response SR directly.

5.2.1: Confirmatory Test

For further support of optimized data which is analyzed under optimum parametric values, the confirmatory test is applied which results are shown as under. The both confirmatory test and calculated results are shown in Table.7.

Table.7: shows the confirmatory results and calculated results

Predicted solutions							
Number	on time	off time	voltage	current	SR	Desirability	
1	30	20	6	8	3.470	0.889	Selected
Experimental results							
Number	on time	off time	voltage	Current	SR	Desirability	
1	10	20	6	8	3.48	0.786	

VI CONCLUSION

The objective of this study was to explore the optimum process conditions, using Taguchi L9 approach, the extensive study carried out during the present work led to following conclusions:

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1) Metal removal rate of the work piece increases with increase in current and pulse on time, the maximum MRR was found out on pulse-on time 30µs, pulse-off time 45µs, voltage6V, current 12A.

2) Surface roughness during the electric discharge machining increases with increase in current and pulse on time, the minimum SR was found out on pulse-on time 10µs, pulse-off time 20µs, voltage6V, current 8A.

3) It is found that all the four machining parameters have significant effect on the response variables considered in the present study.

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