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EXPERIMENTAL ANALYSIS AND OPTIMIZATION OF EDM ON AA6061 USING TAGUCHI TECHNIQUE

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ABSTRACT

Electro Discharge Machining (EDM) is an extremely noticeable machining process among newly developed non - traditional machining techniques are "difficult to machine" conducting materials such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat defiant steels etc. In EDM, the material removal from the work piece is achieved through high frequency sparks generated between the tool and the work-piece material immersed into the dielectric. The Material Removal Rate (MRR), Tool Wear Rate (TWR) and surface integrity are some of the important performance attributes of EDM process. The objective of this study is to get high MRR along with achieving reasonably good surface quality of machined element. The machining parameters that achieve the highest MRR strongly depend on the size of the machining surface i.e. the occupied electrode and work-piece surface.The work has been carried out by conducting a set of experiments using aluminium alloy 6061 work-piece with copper electrode. Important machining parameters like duty cycle,pulse on time & current are considered for investigation. The effect of the machining parameters on the response MRR was investigated.

KEYWORDS: EDM, AA6061, MRR, ANOVA, Dielectric fluid.

INTRODUCTION

Electrical Discharge Machining (EDM) is an abnormal manufacturing process based on exclusion of material from a part by means of a filament of repeated electrical sparks created by electric pulse generators at short intervals linking an electrode tool and the part tobe machined wrapped up in dielectric fluid. At nearby, EDM is a prevalent modulus operation used inindustry for high meticulousness machining of all types of conductive materials such as metallicalloys, metals, graphite, composite supplies or a variety of ceramic materials. The selection of optimized manufacturing conditions is one of the most important aspects to consider in the die dipping electrical discharge machining (EDM) of aluminium alloy 6061, as these conditions arethe ones that are to determine such important characteristics: surface bumpiness, material removal rate (MRR). Aproperly premeditated and accomplish experiment is of the overriding importance for originating clear and truthful conclusions from the investigational observations. Design of experiment is painstaking to be a very useful stratagem for accomplishing these responsibilities. The science of statistical experimental design originated with the occupation of Sir Ronald Fisher in England in 1920s. Fisher founded the fundamental principle of uncertain design and the connected data-analysis technique called Analysis of Variance (ANOVA) during his hard work to improve the defer of agricultural crops. The theory and applications of experimental design and the related technique of reaction surface methodology have been advanced by many sums researchers as Box and huntsman, Box and Draper, Hicks. Various types of matrix are used for preparation experiments to learning several pronouncement variables. Among them, Taguchi's idea makes heavy use of orthogonal-arrays. Dr. Taguchi of Nippon Telephones and Telegraph band, Japan computerized a means based on "orthogonal-array" experimentations which gives much determined "variance" for the experiment with "optimum settings" of be in command of parameters. Thus the supervise of DOE with optimization of be in charge of parameters to attain BEST results was achieved in the Taguchi technique. "Orthogonal Arrays" (OA) make available a set of fighting fitobjective (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are supervise functions of adored output, serve as purpose functions for optimization, assist in data analysis and anticipation of most select outcome. Now a days Taguchi's methodology is distant and spacious used in all over the world for composeexploration resolutions, distinctively to optimise the machining uniqueness. In this paper an endeavor has been made to put single-handedly some of the work done on Taguchi method.

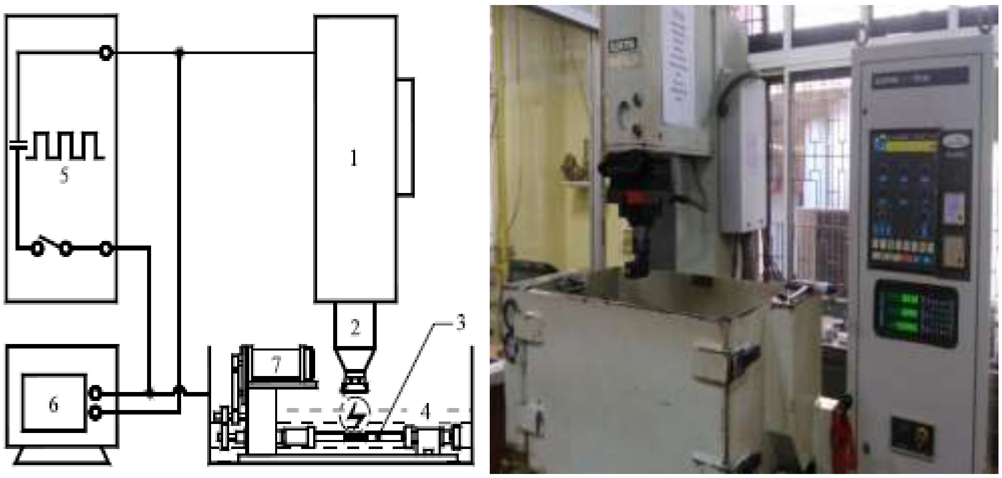

Figure 1.Schematicdrawing of EDM1, Servo-control; 2, electrode; 3, work piece; 4, dielectric fluid; 5, pulse generator; 6, oscilloscope; 7, DC motor

EXPERIMENTAL ANALYSIS

For this experimentation the total work is done by using Electric Discharge Machine, model ELECTRONICA- EMS 5535 (die-sinking type), having condition of programming in the Z-vertical axis and by hand operated X and Y axes. The tool is connected to cathode and the work piece to anode. viable grade EDM oil (specific gravity= 0.763 kg/m3), freezing point= 94°C) was used as dielectric fluid with lateral flushing (pressure of 0.3kgf/cm2) system for effective flushing of machining debris from working gap region.

Aluminium alloy 6061 is one of the the majorityexpansively used of the 6000 series aluminium alloys. It is a resourceful heat treatable extruded alloy with standard to high strength capabilities**.**

Typical properties of aluminium alloy 6061 include:

average to high strength, Good toughness, Good surface finish, exceptional corrosion resistance to atmospheric state of affairs, Good corrosion resistance to sea water, Can be anodized, Good weldability and brazability, good quality workability, Widely existing.

Table 1 Typical composition of aluminium alloy 6061

Mg	Si	Fe	Cu	Zn	Ti	Mn	Cr	Al
0.8-1.2	0.4-0.8	Max 0.7	0.15-0.4	Max.0.25	Max0.15	Max0.15	0.04-0.35	Balance

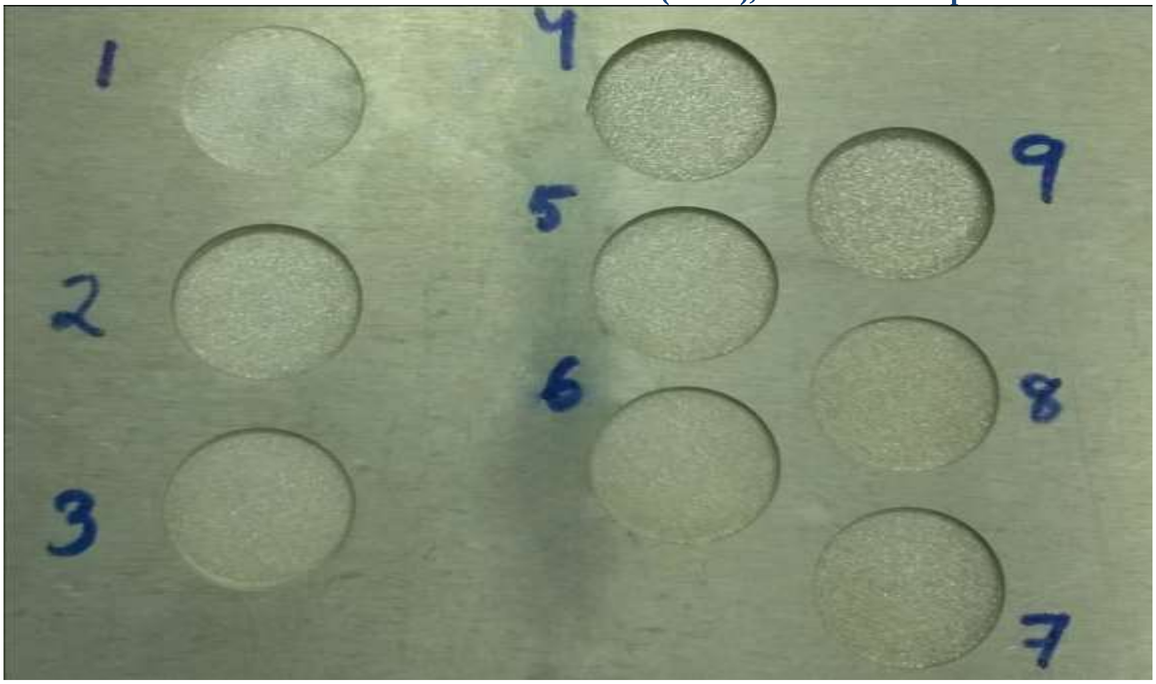

Figure 2 Machined Workpiece

The experiments were conducted on EMS-5535 exactness die sink electric liberation machine as shown in Fig.1 which consist a work table, a servo control system and adielectric supply system. The machine has 3 current settings from 15A to 45A, 3settings of pulse on time 50µs to 150µs, 3 settings of duty cycle 6 to 10 and spark cleft of 50-75 microns. The experiments are conducingt on aluminium 6061 alloy and the work piece dimensions are 152 mm x 90 mm x 6 mm. EDM oil Grade 30 is used as the dielectric fluid and the experiments wereperformed for a particular set of input parameters. The number of experiments and input levels are strong-willed based on the propose of experiments and the enter parameters and their levels are presented in Table 1. The MRR ispreferred as output sfactor which is determine by using formula

$$\text{MRR}= \frac{ELECTRODE\ AREA(IN\ mm^2)*DEAPTH\ OF\ CUT(IN\ mm)}{TIME\ OF\ CUT(IN\text{min})} mm^3/min$$

Table 2 ***parameter and levels***

Parameter	Level 1	Level 2	Level 3
Pulse on time(µs)	50	100	150
Duty cycle	6	8	10
Current(A)	15	30	45

TAGUCHI ORTHOGONAL ARRAY

Orthogonal Arrays (often referred to Taguchi Methods) are frequently employed in industrial experiments to study the outcome of several direct factors. Popularized by G. Taguchi. Other Taguchi assistance contain: Model of the Engineering Design Process, Robust Design Principle, hard work to push quality upstream into the engineering design process An orthogonal array is a type of experiment where the columns for the free variables are "orthogonal" to one another.Benefits: 1. Conclusions valid over the complete region spanned by the be in charge of factors and their setting, large economy in the experimental endeavor , psychotherapy is easy to define an orthogonal array, one must classify.

Table 3 Taguchi L9 Orthogonal Array

Expt. Run	Pulse on time (μs)	Duty Cycle	Current (A)
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

RESULT ANALYSIS

Taguchi's Design of Experiment is a commanding technique for humanizing process designs and solving productions harms and it is well establishedtactic for experimental design. This technique gives the affiliation between the machining parameter and performance parameter successfully. The machining parameters preferred for this experiment are: Pulse on time,Duty cycle & Current. The machining situation and number of level of the parameters elected is shown in Table 2.As shown in Table 4, the investigationalpragmatic values for Depth of cut and MRR are changed in to the signal to noise ratio, it is the quality indicator by which we be capable ofappraise the effect of machining parameter on the performance parameter.

Taguchi method involves dipping the variation in a process through robust design ofexperiments. The overall objective of the method is to produce high quality product atlow cost to the manufacturer. Taguchi urbanized a method for manipulative experimentstoin spect how different parameters affect the stand for and dissent of a process routine characteristic that defines how well the process is functioning. The experimental design projected by Taguchi involves using orthogonal arrays to organize the parameters disturbing the practice and the levels at which they should be varied; it allows for the anthology of the necessary data to conclude which factors most involve product eminence with a least amount amount of conducting tests, thus saving time and property. Taguchi design technique is to make out the parameter settings which render thequality of the product or development robust to obvious variations in external noise. Therelative “quality” of a meticulous parameter design is evaluated using a common signal-to-noise (S/N) ratio. Depending on the particular design problem, different S/N ratiosare applicable, including “lower is better” (LB), “nominal is best” (NB), or “higher isbetter” (HB).As the purpose is to obtain the high material removal rate. It is apprehensive ewith obtaining larger value for MRR, smaller value of tool wear rate and smaller value of surface roughness .Hence, the required excellencecharacteristic for high MRR is larger the better, which states that the amount produced must be as large as possible.

Table 4 Experimental Table

Expt. Run	Pulse on time (µs)	Duty Cycle	Current (A)	Depth of cut(mm)	MRR $\left(mm^3/\min\right)$	S/N Ratio
1	50	6	15	0.165	5.183	14.2916
2	50	8	30	1.275	40.050	32.0521
3	50	10	45	0.905	28.431	29.0758
4	100	6	30	1.460	45.867	33.2300
5	100	8	45	0.950	29.845	29.4974
6	100	10	15	0.720	22.620	27.0899
7	150	6	45	0.915	28.745	29.1712
8	150	8	15	0.660	20.735	26.3341
9	150	10	30	1.615	50.736	34.1063

ANALYSIS OF VARIANCE (ANOVA)

The knowledge of the donation of individual factors is significantly imperative for the direct the concluding comeback.The analysis of variance (ANOVA) is a common statistical method to find out the percent involvement of each feature for results of the experiment. It calculates parameters known as sum of squares SS, degree of freedom(DOF), variance and percentage of each factor. Since the process of ANOVA is a very complex and employs a significant of statistical formula. The Sum of Squares SS(tr) is a calculate of the divergence of the experimental data from the meanvalue of the data. The Fisher’s ratio is also called F value. The principle of the F testis that the larger value for a particular parameter, the greater the effect on the performance characteristics due to the change in that limitation. F value is defined asthe ratio of Mean square for the term to Mean square for the inaccuracy term.All the calculation are done in MINI TAB 16 software. From Table 5, we conclude that the current has the maximum contribution with 61.89% on MRR.

Figure 3 shows that,when Pulse on time increases MRR increases for some values then it is nearly constant, when Duty cycle increases then MRR increases but when current increases then MRR increases significantly then decreases. As MRRfulfils the larger the better criteria, so the optimum points for process parameters are, Pulse on time 100 µs, Duty cycle 10 and Current 30 A.

TABLE 5 Analysis of Variance for SN ratios, R-Sq = 91.0%   R-Sq(adj) = 64.0%

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
Pulse on time	2	45.42	45.42	22.71	1.82	0.354	16.4
Duty cycle	2	35.04	35.04	17.52	1.41	0.415	12.67
Current	2	171.10	171.10	85.55	6.87	0.127	61.89
Residual error	2	24.90	24.90	12.45			
Total	8	276.45					

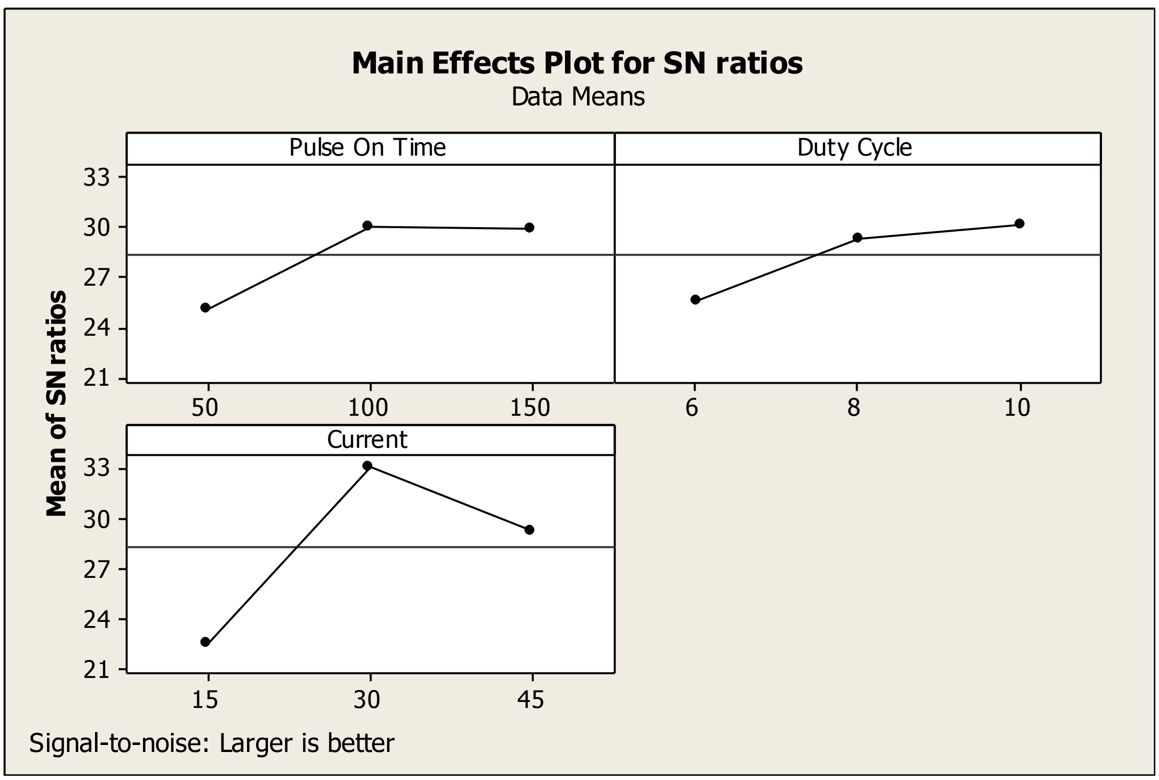

Figure 3 Main Effect plot for MRR

CONFORMATION TEST

In order to validate the results obtained, the substantiation experiments were conducted at the best possible machining parameters. The confirmation experiment were conducted for Material removal rate and results obtained and compared with predicted standards are shown in Table 6.

Table 6 Confirmation test result

.Pulse on Time(μs)	Duty cycle	Current(A)	Depth of cut(mm)	MRR($^{mm^3}/_{min}$)
100	10	30	1.734	54.475

CONCLUSION

The present paper investigated and optimized the machining parameters i.e. Pulse on time, Duty cycle & current for MRR of EDM of aluminium alloy 6061 by using cupper electrode. The significant parameter for MRR is determined by using S/N ratio and ANOVA. The important conclusion summarized below:

From the main effect plot, the optimum parameter setting obtained as Pulse on time 100 µs, Duty cycle 10, Current 30 A. We have conducted a Confirmation test on the same setting and the results of the test give a value of DOC 1.734 and the corresponding value of MRR 54.475$^{mm^3}/_{min}$ which is the optimum MRR.

From Analysis of Variance, we conclude that among all the parameters Current has a significant effect on the response.

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