Experimental investigation of Machining Parameters for Electrical Discharge Machining on Al-6061

Anil Kumar Bodukuri, Prof.K.Eswaraiah, Rajendar Katla.

Abstract— The Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time. Using Copper tool a well-designed experimental scheme was used to reduce the total number ofexperiments. Parts of the experiment were conducted with the L16 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 by the Responses of Material Removal Rate (MRR), Tool Wear Rate (TWR).

Index Terms—Al 6061 alloy, EDM, ANOVA, DOE, Taghuchi L $_{16}$ Array, Pulse on time, Pulse off time, M.R.R, and T.W.R, .

1 Introduction

The EDM has been considered to be one of the best alternatives for machining an ever increasing number of high strength, wear resistant and corrosion resistant materials. EDM is a thermo-electric process in which material removal takes place through the process of controlled spark generation. EDM is one of the most widely employed non-traditional machining processes as it has been accepted as a standard process to manufacture mould and dies of aerospace, automotive, nuclear, surgical, petroleum and marine components. Since EDM does not make direct contact between the electrode and the work material, it eliminates mechanical stresses, chatter and vibration problems during machining (Benedict, 1987). Hence, very hard and brittle materials can also be machined easily and also to the desired form. It removes electrically conductive materials by means of rapid, repetitive spark discharges from a pulsating direct current power supply with dielectric flow between the work piece and the electrode. Considering the challenges brought by advanced technology (Singh et. al., 2004). Further, EDM is relatively simple method to machine very complex geometry with very fine and high precision.

The principle of EDM can be traced as far back as 1770, when English chemist Joseph Priestly discovered the erosive effect electrical discharges or sparks. However it was only in 1943 at the Moscow University where Lazarenko and Lazarenko (Mishra, 2005) exploited the destructive properties of electrical discharges for constructive purpose. They developed a controlled process for the metals which have poor machinability vapourising material from the surface of metal. The Lazarenko EDM system used resistance-capacitance type of power supply, which was widely used at the EDM machine in the 1950s and later served as the model for the successive development in EDM.

The material erosion mechanism primarily makes use of electrical energy and turns into thermal energy through a series of discrete electric discharges occurring between the electrode and the workpiece immersed in a dielectric fluid which is shown in Fig. 1. The thermal energy generates a plasma between the cathode and anode at a temperature in the range of 8000 to 120000C or as high as 200000C initializing a substantial amount of heating and melting of material at the surface of each pole. When the pulsating direct supply current released at the rate of approximately 20,000-30,000 Hz is turned off, the plasma channel breaks down. This causes a sudden reduction in the temperature which allows the circulating dielectric fluid to implore the plasma channel and flush the molten material from the pole surfaces in the form of microscopic debris (Mishra, 2005). This process of melting and evaporating material from the workpiece surface is completely contrast to the conventional machining processes, as chips are not mechanically produced. The volume of material removed per discharge is typically in the range of 10-6 to 10-4 mm3 and the material removal rate (MRR) is usually between 2 mm3/min and 400 mm3/min depending on specific application. Since the shaped electrode defines the area in which spark erosion occurs, the accuracy of the part produced after EDM is fairly high. After all, EDM is reproductive shaping process in which the form of the electrode is mirrored in the workpiece.

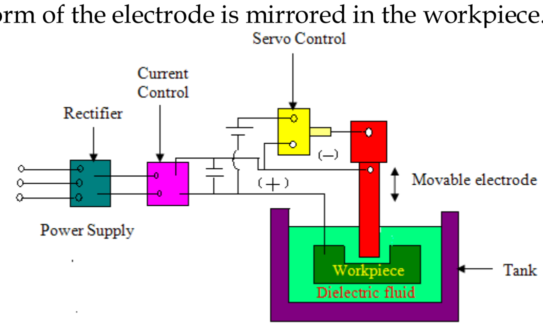

Figure 1 Schematic **diagram of EDM**

The base material used in this study was aluminum alloy Al

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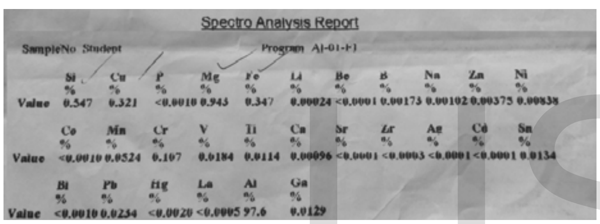
ISSN 2229-5518

6061 plates thickness of 5 mm. Aluminum alloys 6061 is one of the most extensively used of the 6xxx series aluminum alloys. It is a versatile heat treatable extruded alloy with medium to high strength capabilities. Aluminum alloys are designated based on international standards. These alloys are distinguished by a four digit number which is followed by a temper designation code. The first digit corresponds to the principal alloying constituent. The second digit corresponds to variations of the initial alloy. The third and forth digits correspond to individual alloy variations .Finally the temper designation code corresponds to different strengthening techniques. The chemical composition is given in figure-1. Mechanical and physical properties are given in Tables -1 respectively. The Al-6xxx are aluminum/magnesium/silicon alloys (magnesium and silicon additions of around 1.0%) and are found widely throughout the welding fabrication industry ,used predominantly in the form of extrusions and incorporated in many structural components. It is typically used in Architectural applications, ship vessels, aircrafts, extrusions, window doors and shop fittings.

AA-6061 as fabricated posses

(i). Workability – Cold: Good

(ii). Machinability: Acceptable



Spectro Analysis Report

SampleNo Student Program Al-01-F1

	Si	Cu	P	Mg	Fe	Li	Be	B	Na	Zn	Ni
	%	%	%	%	%	%	%	%	%	%	%
Value	0.547	0.321	<0.0010	0.945	0.347	0.00024	<0.0001	0.00175	0.00102	0.00375	0.00838

	Co	Mn	Cr	V	Ti	Ca	Sr	Zr	Ag	Cd	Sn
	%	%	%	%	%	%	%	%	%	%	%
Value	<0.0010	0.0524	0.107	0.0184	0.0114	0.00096	<0.0001	<0.0003	<0.0001	<0.0001	0.0134

	Bi	Pb	Hg	La	Al	Ga
	%	%	%	%	%	%
Value	<0.0010	0.0234	<0.0020	<0.0005	97.6	0.0129

Figure 2 Typical composition of aluminum alloy 6061

Component	**Amount (wt.%)**
Aluminium	**Balance**
Magnesium	**0.8-1.2**
Silicon	**0.4 – 0.8**
Iron	**Max. 0.7**
Copper	**0.15-0.40**
Zinc	**Max. 0.25**
Titanium	**Max. 0.15**
Manganese	**Max. 0.15**
Chromium	**0.04-0.35**
Others	**0.05**

Table 1: Composition of Al-6061

2 EXPERIMENTAL WORK

The experiments were performed on ASKAR MICRONS-V3525 EDM. The basic parts consist of a copper electrode, a work table, a servo control system, a power supply and dielectric supply system. The gap between wire and work piece is0.02 mm and is maintained by a computer controlled positioning system. copper electrode of diameter is used and work piece of 6061 Al alloy plate is used.

2.1. Taguchi method.

Taguchi methods are statistical methods developed by **Genichi Taguchi** it is one of the most powerful DOE methods for analyzing of experiments. It can be used to improve the quality of manufactured goods, and more recently also applied to [5]engineering biotechnology, marketing and advertising. Taguchi first applied his methods was Toyota. Since the late 1970s.

2.2. Taguchi method- based design of experiments.

This involved the following steps [7].

1. Definition of the problem
2 .Identification of noise factors
3. Selection of response variables
4. Selection of process parameters and their levels
5. Selection of the orthogonal array
6. Material Data
7. Experimental procedure and set-ups
8. Results of the data and prediction of optimum level

Table 3: The basic Taguchi L16(4^3) orthogonal array

Run order	CURRENT	PULSE ON	PULSE OFF	M.R.R	T.W.R
1	6	7	7	0.15	0.009
2	6	8	8	0.14	0.010
3	6	9	9	0.08	0.090
4	6	10	10	0.09	0.004
5	12	7	8	0.74	0.077
6	12	8	7	0.96	0.096
7	12	9	10	0.51	0.080
8	12	10	9	0.46	0.027
9	18	7	9	1.65	0.080
10	18	8	10	0.67	0.070
11	18	9	7	0.64	0.080
12	18	10	8	0.29	0.040
13	24	7	10	0.67	0.080
14	24	8	9	1.33	0.120
15	24	9	8	1.16	0.120
16	24	10	7	0.44	0.080

Product robustness, pioneered by Taguchi, uses experimental design to study the response surfaces associated with both the product means and variances to choose appropriate factor settings so that variance and bias are both small simultaneously. Designing a robust product means learning how to make the response variable insensitive to uncontrollable manufacturing process variability or to the use conditions of the product by the customer.

Taguchi defines three quality characteristics in terms of

ISSN 2229-5518
signal to noise (S/N) ratio which can be formulated for different categories which are as follows [6]:

2.3. Small are best characteristics.

Data sequence for Tool wear rate, which is smaller-the-better performance characteristics, is pre processed as per equation 1.

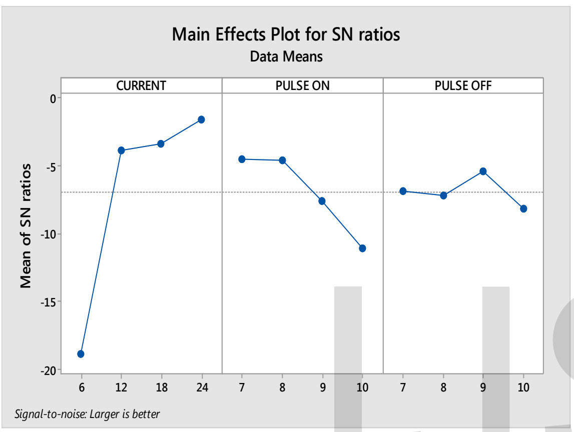
. S/N = -10 log ((l/n) (Σy2))………..……1

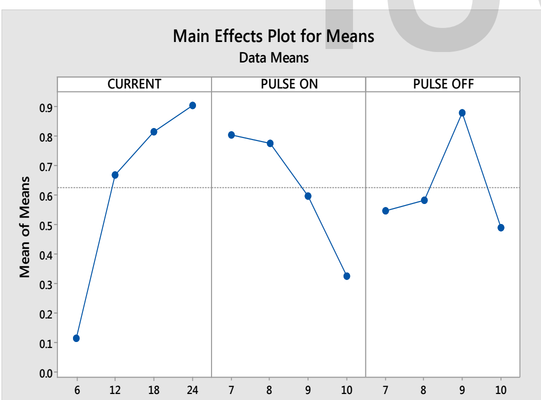
2.4 Larger is best characteristics.

Data sequence for material removal rate, which is higher-the-better performance characteristics, is pre processed as per equation 2.

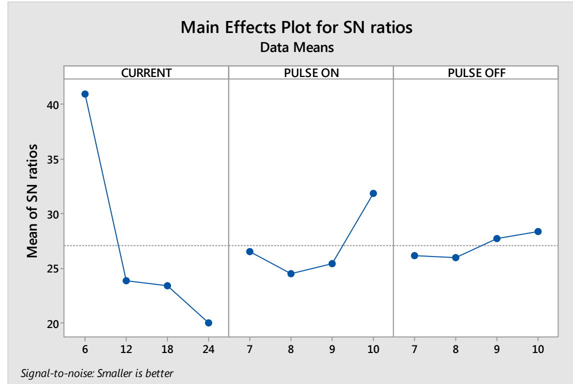
S/N = -10 log ((1/n) (Σ (1/y2))……..…2

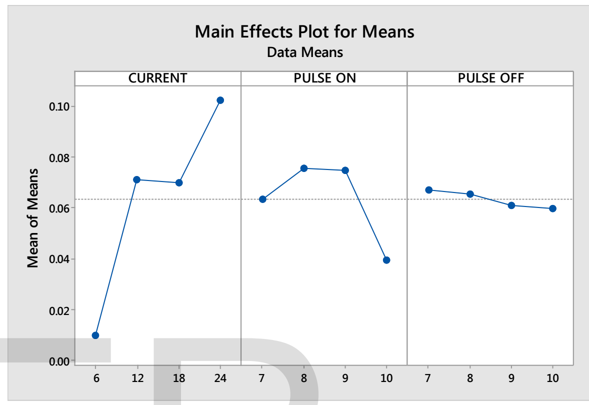
where, *y* is value of response variables and *n* is the number of observations in the experiments.





From the above table the mean and S/N ratios are obtained from software MINITAB 17. In order to assess influence of factors on response, means and signal-to-noise (S/N) for each control factor are calculated





. Signals are indicators of effect on average responses and noises are measures of deviations from experiment output. Appropriate S/N ratio must be chosen using previous understanding of the process. In this study, S/N ratio was chosen according to criterion, larger-the-better, in order to maximize response of M.R.R and small is best in order to minimize the Tool Wear Rate. In Taguchi method, S/N ratio is used to determine deviation of quality characteristics from desired value.

3. Conclusions:

In this paper, a study of the influence of three erosion parameters (current intensity, pulse on time and pulse off time) on M.R.R and electrode wear rate in Electric Discharge Machining of AL-6061 plate has been performed.

Regarding electrode wear, current intensity and pulse time are the factors which have more influence on the response. For minimal electrode wear, high pulse time and high current intensity should be applied.

For high current intensity values, the best results are achieved with high pulse time and for low current intensity values,best results are obtained with low pulse time.

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