WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Optimization of Process Parameter for Aluminium Alloy 6061 and 7075 Processed in Wire-CutEDM

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ABSTRACT

Aluminium has found expanding application in industries, automobiles, aerospace, and medical field etc. the surface roughness of Aluminium in depends on MRR, where it is proceeded on wire cut EDM. In this project, investigate the MRR of two grades of Aluminium while surface roughness which is proceed by wire-cut EDM by varying the process parameter such as pulse on time, pulse off time, peak current and servo voltage. Further analysis in optical microscope and surface roughness tester to find the correct parameter of EDM for machining of Aluminium. We use two grades of aluminium 6061 and 7075. Both grades are compared and optimized.

Keywords: Pulse timing; Current and voltage; Material removal rate; Surface roughness.

1 . INTRODUCTION

Aluminium metal and its alloys are implemented in most, if not all modern industrial processes due to its wide availability and the vast number of uses. An alloy is a metal made by combining two or more metallic elements to achieve improved material properties. The process of alloying involves adding specific metallic “alloying” elements into a base metal to give it distinct properties such as increased strength, corrosion resistance, conductivity, toughness, etc., or a desired combination of these traits. Alloys with low percentages of alloying elements (around <4%) are classified into wrought alloys and are workable, whereas those with higher percentages (up to 22%) are classified into cast alloys and are usually brittle. The Aluminum Association (AAInc.) is the foremost authority on aluminum alloys and has developed a four-digit naming system used tocharacterize distinct wrought alloys from one another based on their main alloying elements. In this article, 6061 aluminum alloy will be discussed in detail, highlighting its physical properties as well as the common applications for this highly useful material

Aluminium alloy 6061 has Density of 2.7 g/cm^3 and tensile Strength 310MPa. It has a melting point of 413^0 C up to 90 min. Alloy 7075 has density of 2.81g/cm^3 and tensile strength 572 Mpa. It has a melting point of 477^0 C.

Ghodekar P.A and Tajane Ravindra. S [1] has investigated Surface roughness and MRR of AA6063 of Aluminium Alloy. Able to give the output of Surface finish Ra= 2.3963 and material removal rate (MRR)= 16.23mm^3/min. For maximization of MRR, the highest level of Pulse on time, middle level Pulse off time, moderate level Wire feed and wire tension; whereas minimization of surface roughness middle level pulse on time and pulse off time with highest wire feed rate and lowest wire tension isrequired.

Ravindranadh Bobbili, V. Madhu and A.K. Gogia. [2] they took ballistic grade aluminium alloy Results confirm that TON,IP and SV are significant variables to Grey relational grade. Mathematical models were developed using response surface method for MRR, SR and IG to determine the relation between machine variables and performance measures. Optimum response characteristics such as MRR, SR and GC are improved with 6% error by employing Grey relational analysis.

Harsimran singh and Harmesh kumar.[3] Research work proves that WEDM is an adequate process to machine aluminium matrix composites with good surface finish and dimensional precision. Machining rate of composite is significantly affected by the kind of reinforcement. To investigate the influence of reinforcement research work is important, but the influence of % volume of reinforcement cannot be predicted.

Patel and Maniya [9] demonstrated that surface uprightness investigates of Nimonic 80A alloy promoting thread-cut EDM. Ton, Toff, IP, WF, WT, and SV are recommendation limits and the yield responses by MRR, SR and thread wear percentage. It’s fatigued that trim cut produce forms, Ton has raise for the big influencing variable of the MRR (52.31 %) and SR (74.69 %).

2.EXPERIMENTAL PROCEDURE

The experimental work has happened done on Wire-cut electric discharge machine. This machine plans have four meaningful substitute- elements to be a capacity supply part, dielectric whole, positioning whole, and drive part. The capacity supply unit contain DC high voltage transmission revolution. Dielectric part amount to de-ionized water accumulation, filtration system, draining arrangement. The sticking unit is containing two mechanical mathematical control tables. It works in a flexible control manner for fear that on the wire visits at nearer
to the workpiece, or the breach is hindered over by waste and causes a short circuit, the arranging part able to detect it. The drive whole steadily forceful the new wire, and steadily assets the cable tension accompanying the aim that it moves in the produce district as a straight wire. Additionally, it helps in confining thread break, decrease, streaks just as shaking marks [2].
Analyses were acted on a wire-cut EDM machine design while established portion, exciting table set accompanying a size of 250
× 350 mm, capacity supply 3 step, AC 415 V, 50 Hz. The 0.18 mm width of molybdenum wire concerning be secondhand for hateful tool while de-ionized water was secondhand as a coolant. In this exploratory work Aluminium alloy 6061 and 7075 has existed preferred as the workpiece material to its monetary and industrialized significance in the aerospace industry, healing implants, car activities, etc. The process limits impact the wire-cut EDM process are widely organized in three categories: power supply related: type of supply, current, voltages, pulse times; Wire related: Wire type, wire material, Size of wire; workpiece accompanying and others: workpiece material, build occasion, produce domain. Right now, on schedule, rhythm according to schedule, pulse- off time, peak current and servo voltage are applyied as recommendation limits.

Fig-1 Machining pieces of 6061

1. Work Material: Aluminium 6061
2. 2.Wire feed: 5 min / min
3. wire diameter : 0.18 mm.
4. work piece dimension: 10 x 10 mm 5.Thickness: 12 mm

Table-1 Parameter range for 6061

S.No	Parameter	Range
1	Pulse-on time(P_{on})	120 - 126µs
2	Pulse-off time(P_{off})	54 - 60 µs
3	Peak current(IP)	210 – 230 A
4	Servo voltage(SV)	20 – 25 V

Table-2 Levels of parameter for 6061

Parameter	Level-1	Level-2	Level-3
Pulse-on time(p_{on})	120	122	126
Pulse-off time (P_{off})	54	56	60
Peak Current (I_p)	210	220	230
Servo Voltage(S_V)	20	22	25

Table- 3 Parameter range for 7075

S.No	Parameter	Range
1	Pulse-on time(P_{on})	125 - 128µs
2	Pulse-off time(P_{off})	54 - 60 µs
3	Peak current(IP)	210 – 230 A
4	Servo voltage(SV)	20 – 25 V

Table-4 Levels of parameter for 7075

Parameter	Level-1	Level-2	Level-3
Pulse-on time(p_{on})	125	126	128
Pulse-off time (P_{off})	54	56	60
Peak Current (I_p)	210	220	230
Servo Voltage(S_V)	20	22	25

3.RESULTS

3.1 MRR Calculation

During the machining process, the spark will be produced. The spark developed the high-temperature which causes the melted or vaporize the material from workpiece. This vaporized material can be calculated by,

MRR = $k \times t \times$ F.R $\times \rho$ …(i)

Fig-2 Machining pieces of 7075

1. Work Material: Aluminium 7075 2.Wire feed : 5 min / min 3.wire diameter : 0.18 mm.
4. work piece dimension: 10 x 10 mm 5.Thickness: 5mm

Where,

MRR - Material removal rate in g/min

k - Kerf in mm (*0.18 mm*)

t- Thickness of workpiece inmm (*12 mm*)

F. R - Cutting speed in mm/min

ρ- Density of workpiece g/cm^3

The material removal rate has been calculated by using equation (i),

Table-5 Material removal rate values for 6061

NO	P_{on}(μs)	P_{off} (μs)	I_p (A)	S_V(V)	F.R(mm /min)	MRR(g /min)
1	120	54	210	20	148.7	0.8672
2	120	56	3	22	152.8	0.8911
3	120	60	4	25	156.7	0.9138
4	122	54	3	25	154.2	0.8992
5	122	56	4	20	153.9	0.8975
6	122	60	2	22	150.1	0.8753
7	126	54	4	22	157.6	0.9191
8	126	56	2	25	151.0	0.8806
9	126	60	3	20	155.1	0.9045

Table-6 Material removal rate values for 7075

NO	P_{on} (μs)	P_{off} (μs)	I_p (A)	S_V(V)	F.R(mm /min)	MRR (g/min)
1	125	54	210	20	146.7	0.3710
2	125	56	220	22	150.8	0.3813
3	125	60	230	25	152.7	0.3861
4	126	54	220	25	153.2	0.3874
5	126	56	230	20	156.9	0.3968
6	126	60	210	22	152.1	0.3846
7	128	54	230	22	151.6	0.3833
8	128	56	210	25	157.0	0.3970
9	128	60	230	20	154.1	0.3897

From both table 5 and 6 the pulse timing and peak current is more contribute factor to material removal rate. Particularly the pulse-on time and peak current while increase their material removal rate is always increase.

3.2 Surface roughness

Surface roughness values carried out by using surface roughness tester (Mitutoyo SJ-201). These experiments, the surface roughness values as displayed on the surface roughness tester. From table-7 and 8, pulse on time is having the highest significant factor to surface roughness.

Table-7 Surface roughness values for 6061

No	P_{on}(μs)	P_{off}(μs)	I_p (A)	S_v(V)	SR(μm)
1	120	54	210	20	2.11
2	120	56	220	22	2.39
3	120	60	230	25	2.53
4	122	54	220	25	2.89
5	122	56	230	20	3.12
6	122	60	210	22	3.21
7	126	54	230	22	3.67
8	126	56	210	25	3.87
9	126	60	230	20	3.92

Table-8 Surface roughness values for 7075

No	Pon(μs)	Poff(μs)	Ip (A)	Sv(V)	SR(μm)
1	125	54	210	20	1.17
2	125	56	220	22	1.18
3	125	60	230	25	1.25
4	126	54	220	25	1.28
5	126	56	230	20	1.32
6	126	60	210	22	1.43
7	128	54	230	22	1.48
8	128	56	210	25	1.97
9	128	60	230	20	1.98

4.DISCUSSION

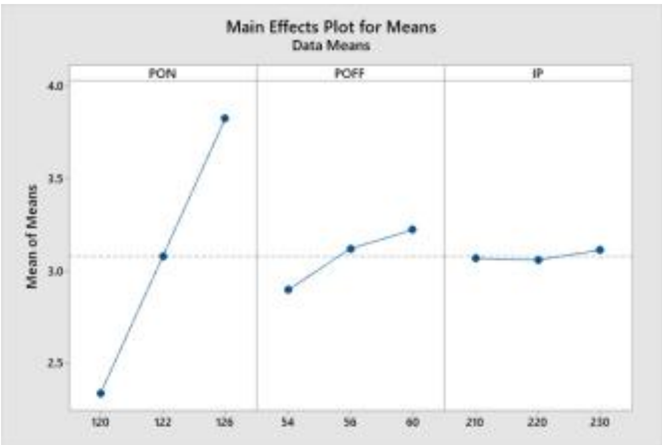
4.1 Optimization Technique

The orthogonal designs can be utilized to pertinent two-level factorial assessments as well as can explore fundamental impacts when variables have multiple levels [1]. The Design of tests is led utilizing Taguchi's technique where the quantity of parameters is three with three degrees of every parameter having the principal level a lower limit and the subsequent level as middle of as far as possible and the third level is as far as possible for that variable. There are numerous standard orthogonal arrays from which required one can be chosen depend on different conditions.

The outcomes got from the trials were investigated utilizing analysis of variance to discover the significance of each input factor on the proportions of process performance, material removal rate and surface roughness. ANOVA is formulated for identifying significant factors. The percentage contribution of each parameter is calculated and the maximum contribution is observed. General linear model MRR versus Pon, Poff, IP The higher estimated value of F- ratio shows that any little variation of the procedure parameter can make a noteworthy impact on the performance characteristics. Because the longer pulse duration, which leads to discharge high energy. Its causes to remove more material from the work piece.

Optimization for 6061 Response Table for surface roughness

Level	PON	POFF	IP
1	2.335	2.896	3.067
2	3.079	3.120	3.059
3	3.824	3.222	3.112
Delta	1.489	0.326	0.053
Rank	1	2	3



Analysis of Variance for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj	F	P
PON	2	3.32568	3.32568	1.66284	1002.72	0.001
POFF	2	0.16665	0.16665	0.08333	50.25	0.020
IP	2	0.00499	0.00499	0.00249	1.50	0.399
Residual Error	2	0.00332	0.00332	0.00166		
Total	8	3.50064				

Optimization of 7075

Response Table for Surface Roughness

Level	PON	POFF	IP
1	1.200	1.310	1.523
2	1.343	1.490	1.480
3	1.810	1.553	1.350
Delta	0.610	0.243	0.173
Rank	1	2	3

Analysis of Variance for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Pon	2	0.61042	0.61042	0.30521	17.53	0.054
Poff	2	0.09562	0.09562	0.04781	2.75	0.267
Ip	2	0.04882	0.04882	0.02441	1.40	0.416
Residual Error	2	0.03482	0.03482	0.01741		
Total	8	0.78969				

4.CONCLUSIONS

The energy supplied into the discharge gap is dependent upon voltage and current. Hence, increases in either of the parameter increase in MRR. For surface roughness, which pulse on time and pulse off time are significant factors. Pulse on time has the most elevated factor of surface roughness. The wire-cut EDM has a better surface finish without cracks on machining surface compared with the electric discharge machine.

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