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PARAMETER OPTIMIZATION FOR WIRE-CUT ELECTRICAL DISCHARGE MACHINING OF AA 6061 ALLOY/MG SI WITH TAGUCHI METHOD

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Abstract
Cold work applications such as aluminium extrusion, It is popular for visible architectural applications such as window frames, door frames, roofs, and sign frames that require high toughness, wear resistance, compressive strength, high corrosion resistance, high surface finish, and complex profiles.AA 6061 is an aluminium alloy that contains magnesium and silicon as alloying components. This material can meet the standards listed above. Because of its hardness and strength, AA 6061 is difficult to manufacture using typical machining procedures,When there is no acceptable traditional machining technique to achieve the essential criteria effectively and inexpensively, advanced machining procedures are applied.Because of its tight tolerances and excellent surface quality, Wire-Cut Electrical Discharge Machining is used.Based on an extensive literature review, it was discovered that relatively few works on WEDM of AA 6061 had been reported In this study, the parameters pulse on time, pulse off time, peak current, wire speed, wire tension, and flushing pressure of dielectric media are evaluated, and their influence on performance measures such as metal removal rate (MRR) and surface roughness is investigated experimentally.Using the Taguchi method, the parameters under consideration will be optimized for maximum MRR and minimal Surface roughness individually. The Taguchi technique will be used to obtain mean S/N ratios in order to determine the best process parameters. These ideal settings can be tweaked to increase Wire-Cut Electrical Discharge Machining
performance.
Key words:MRR,WEDM,optimization,Machining Taguchi method, Tolerance.

1.Introduction

Electrical discharge machining (EDM) is a novel thermoelectric method that removes material from a work piece by firing a series of discrete sparks between a work and tool electrode submerged in a liquid dielectric medium. These electrical discharges melt and vaporise small quantities of work material, which is subsequently expelled and washed away by the dielectric. The frequency of the sparks continually removes the work piece material by melting and evaporation. The dielectric functions as a deionizing medium between two electrodes, and its flow evacuates hardened material debris from the gap, ensuring ideal spark generating conditions.Both EDM and WEDM have similar material removal methods, however their functional features differ. WEDM primarily needs a thin wire to be constantly fed into the work piece by a microprocessor-based control system that supports different complicated elements such as forms that are machined with more precision. Because of these benefits, WEDM can make various types of micro shaped holes, micro gears, complicated micro components and dies, and so on with greater performance than other machining processes. The WEDM machine was developed in accordance with the needs of the product for industrial application, using the same concept as EDM.

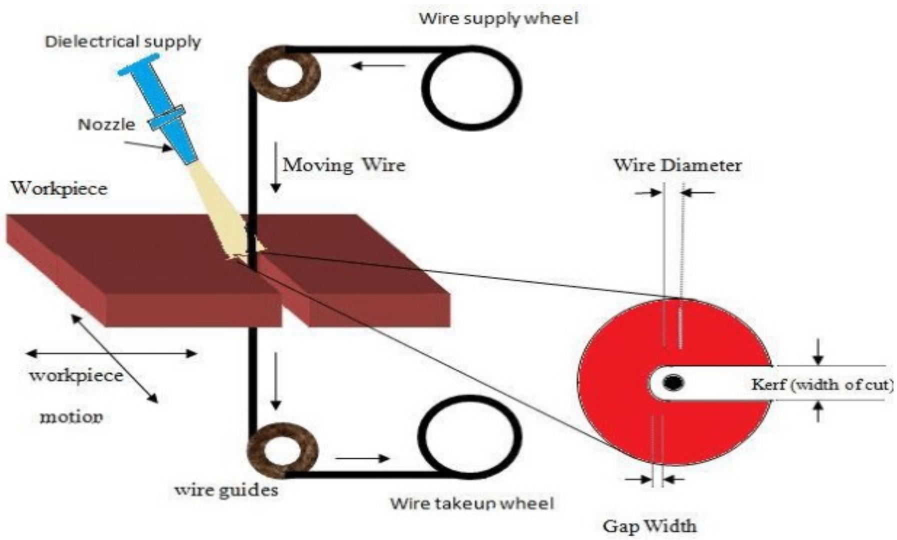


Figure.1 Cutting mechanism of WEDM

1.1 The process parameters of WEDM

Pulse On Time (T_{on})

It's also referred to as spark on time or pulse width. It denotes the duration of the spark.The time range is 0-1000µs.

Pulse off Time (T_{off})

It is often referred to as spark off time or downtime. It refers to the period elapsed between the generation of sparks. The molten metal is removed at this time. It is set to a value between 0 and 1000 µs.

Voltage (V)

The voltage differential between the electrode and the work piece. It is adjusted to a voltage range of 40-200V.

Peak current (I/p)

It refers to the spark's electric current value. It is shown in the unit of amp(A), with a range of 0.5-400 amp.

Performance measures

Material removal rate (MRR):

$$MRR = \frac{wi - wf}{t \times \rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

wire wear rate:

surface roughness (ra):

2. Materials and Methodology

The Taguchi approach relies heavily on process parameter optimization to attain excellent quality while minimizing costs. The best process parameters are chosen not only to increase quality, but also to be the least susceptible to changes in environmental circumstances. Essentially, traditional process parameter design is complicated and difficult to utilize. When the number of process parameters rises, several experiments must be performed. To address this issue, the Taguchi technique employs a unique orthogonal array design to examine the whole process parameter characteristics with a limited number of tests.The difference between the experimental and intended values is then calculated using a loss function. Taguchi suggests using the loss function to quantify performance characteristics that deviate from the target value. The loss function result is then converted into a signal-to-noise (S/N) ratio. In the examination of the S/N ratio, there are three types of performance characteristics: lower-the-better, higher-the-better, and nominal-the-better. Based on the S/N analysis, the S/N ratio for each level of process parameter is derived.

2.1 Orthogonal Array Experiment

Peak current, pulse on time, and pulse off time are the three criteria used for this investigation. The next step is to choose an orthogonal array that is suited for the job at hand. The orthogonal array's degrees of freedom should be more than or equal to those of the machining parameters. An L9 orthogonal array is employed in this investigation. This array contains three columns and nine rows, and it can only accept three-level cutting parameters. As a result, only nine tests are required to investigate the whole cutting factor space using the L9 orthogonal array.

2.2 Computational procedure

The experimental results are then converted into a signal-to-noise (S/N) ratio. Depending on the sort of qualities, many S/N ratios are available. 'greater is better, HB' refers to the property that a greater number signifies better machining performance, such as MRR. In contrast, the property that a lower number reflects superior machining performance, such as surface roughness, is referred to as 'lower is better, LB. As a result, "HB" for the MRR, 'LB" for the SF, and "LB" for the kerf were chosen to achieve the best machining performance.

L_{HB} = $(1/n\Sigma^{n}_{j=1} 1/y^{2}_{j})$**……………………………………(2)**

S/N ratio for MRR = $-10log1/n(\Sigma^{n}_{j=1} 1/y^{2}_{j})$**………..(3)**

L_{LB} = $(1/n\Sigma^{n}_{j=1} y^{2}_{j})$**………………………(4)**

S/N ratio for SR = $-10log1/n(\Sigma^{n}_{j=1} y^{2}_{j})$**……………..(5)**

Table.1 Material properties of Brass wire

S.no	Properties	Value
1	Young's modulus(GPa)	110
2	Shear modulus(GPa)	40
3	Poisson's ratio	0.5
4	Density(g/cc)	9

5	Melting point(°C)	900
6	Thermal conductivity(W/mK^0)	115
7	Electrical resistivity	7.5

Table.2 Machining parameters and their levels

Parameter	Level 1	Level 2	Level 3
Peak Current	12	14	16
Pulse on Time	102	114	122
Pulse off Time	58	69	75

Table.3 L9 Orthogonal Array

Test Case	Peak Current	Pulse onTime	Pulse off Time
1	1	1	1
2	1	2	2
3	1	3	3
4	2	3	2
5	2	1	3
6	2	2	1
7	3	2	3
8	3	3	1
9	3	1	2

Table.4 Experimentation Values for different peak current,pulse on and off time

S.no	Peak Current	Pulse on Time	Pulse off Time	MRR(mm^3/min)	SR(µm)
1	12	102	58	4.2650	1.96
2	12	106	61	6.3145	2.69
3	12	108	64	8.8997	2.98
4	14	114	69	10.4317	3.13
5	14	118	70	11.9872	3.45
6	14	116	70	13.9685	3.89
7	16	122	75	14.3789	4.19
8	16	124	77	16.7890	4.51
9	16	128	78	16.9981	4.97

3.Results and Discussion

Table.5 S/N ratios for MRR

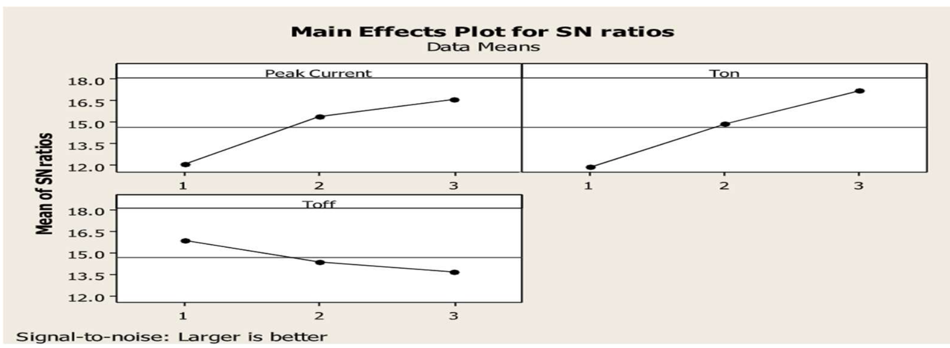
S.no	S/N RATIO
1	13.36
2	13.91

3	14.79
4	17.78
5	18.21
6	19.46
7	21.56
8	23.76

Table.6 Average S/N ratios for MRR

LEVEL	I/P	T_{ON}	T_{OFF}
1	12.42	2.38	3.45
2	16.54	6.22	3.91
3	1.85	6.97	6.33

Graphs related to MRR



Graph.1 Average S/N ratios of MRR V/S Levels

Table.7 Optimum process parameter values for MRR

Parameter	Level	Optimal Value
Peak Current	3	16Amp
Pulse onTime	3	128µsec
Pulse off Time	1	62µsec
MRR		14.467mm^3/min

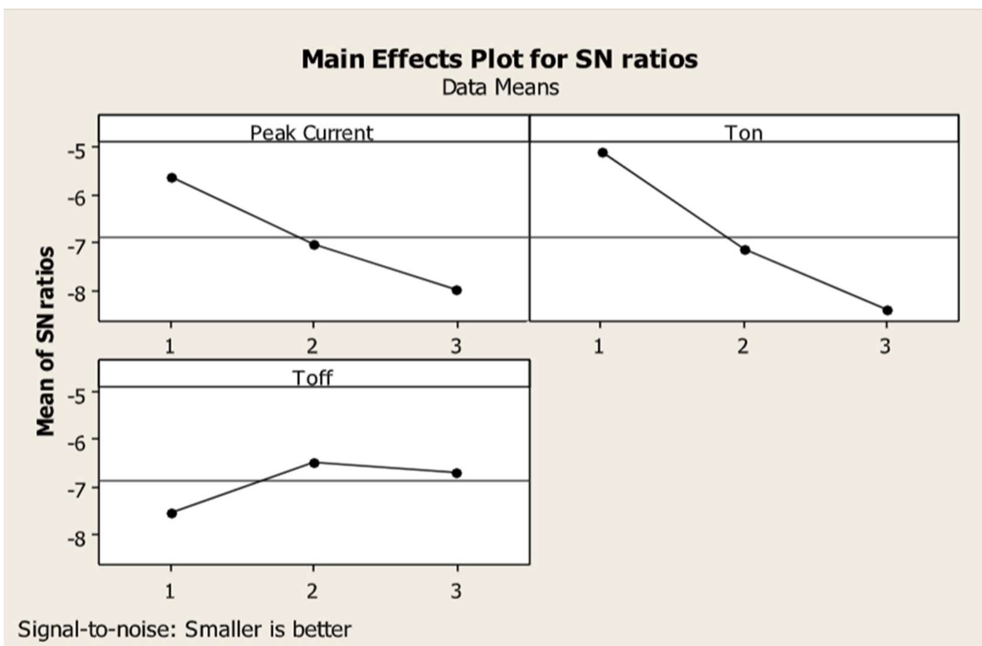
Table.8 S/N ratios of SR

S.no	S/N RATIO
1	-6.783
2	-7.821
3	-8.238
4	-6.431
5	-8.816

6	-8.105
7	-9.563
8	-10.489

Table.9 Average S/N ratios of SR

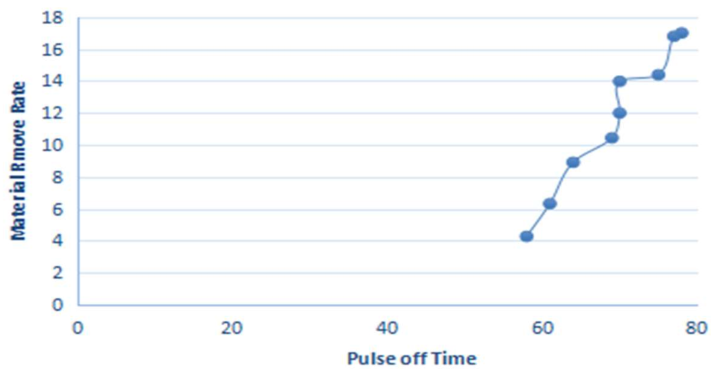
LEVEL	I/P	T_{ON}	T_{OFF}
1	-6.652	-6.201	-8.348
2	-7.812	-7.106	-6.456
3	-9.556	-7.765	-6.875



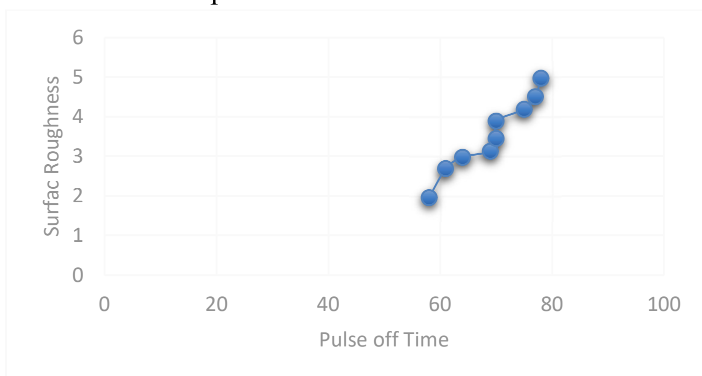
Graph.2 Average S/N ratios of SR v/s Levels

Table.10 Optimum process parameter values of SR

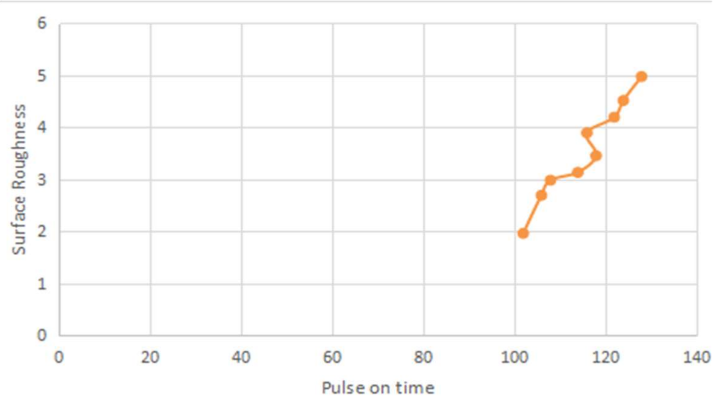
Parameter	Level	Optimal Value
Peak Current	1	14Amp
Pulse onTime	1	114µsec
Pulse off Time	2	64µsec
MRR		2.486



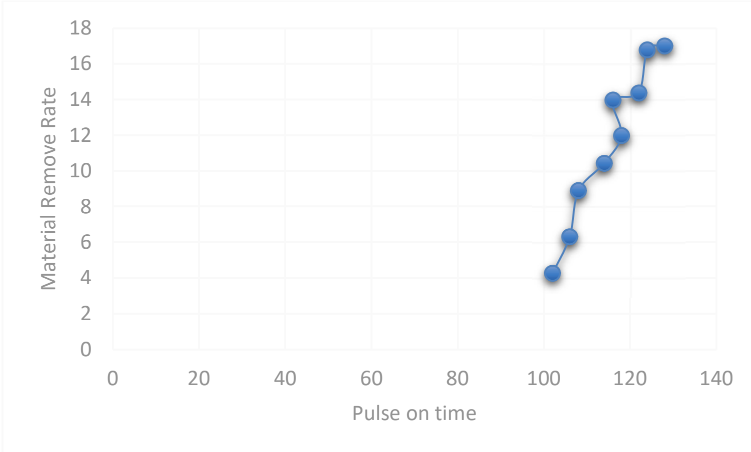
Graph.3 Pulse off time vs MRR



Graph.4 Pulse off time vs SR



Graph.5 Pulse on time vs SR



Graph.6 Pulse on time vs MRR

3. Conclusion

To determine the significant machining parameters for performance measures like MRR and SR separately of AA 6061 by using Wire-Cut Electrical Discharge Machining process.The machining parameters, such as pulse on time, WF rate, and FP, for the responses such as MRR and surface roughness were optimized for the Wire-Cut Electrical Discharge Machining process process using Taguchi L9 orthogonal array.Taguchi method is used to obtain optimum process parameters combination for maximization of MRR and minimization of SR. The confirmation experiments were conducted to evaluate the result predicted from Taguchi Optimization.From the obtained results, it is clear that while performing the WEDM process,AA6061/Mg Si gives a better surface finish and better MRR as per the requirement.

References

1) Shi J, Wang Y. Development of metal matrix composites by laser-assisted additive manufacturing technologies: a review. J Mater Sci. 2020;55(23):9883–917. https://doi.org/10.1007/s10853-020-04730-3

2) Choudhary R, Kumar A, Raj H, Kumar S, Tiwari S, Khan S, et al. Fabrication and characterization of stir cast Al2024/SiCp metal matrix composite. Mater TodayProc. 2020; https://doi.org/10.1016/j.matpr. 2020.02.471

3) Coyal A, Yuvaraj N, Butola R, Tyagi L. An experimental analysis of tensile, hardness and wear properties of aluminium metal matrix composite through stir casting process. SN Appl Sci. 2020;2:892. https://doi.org/ 10.1007/s42452-020-2657-8

4) Adebisi A, Maleque M, Rahman MM. Metal matrix composite brake rotor: historical development and product life cycle analysis. Int J Automot Mech Eng. 2011;4(1):471–80.

5) Bae W, Kim S, Kim Y, Lee S-K. Suppression of machine tool spindle vibration by using TiC-SKH51 metal matrix composite. Compos Res. 2020;33(5):262–7. https://doi.org/10.7234/composres.2020.33.5.262

6) M.Dhanunjay and M.Maduletti, The process of EDM cutting parameters optimising by using Taguchi method and Anova on Inconel 718 International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 12 | Dec 2018 .

7) Kuriachen Basil and Dr.Joseph kunju, Investigates the effect of voltage, dielectric pressure, pulse on-time and pulse off-time on spark gap of Ti6AL4V alloy International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 1, January 2013.

8) Bawa M, Umaru O, Abur B, Salako I, Jatau J. Ef- fect of locust bean pod ash on the hardness and wear rate of heat treated A356 alloy metal matrix composite for production of automobile brake rotor. Eng Technol. 2020;57(1):36–43. https://doi.org/10.47119/IJRP100571720201325

9) Mason CJT. Structure-property-process relations of solid-state additively manufactured aerospace aluminum alloys. University of Alabama Libraries; United States of America, 2020.

10) Mallick PK. Materials, design and manufacturing for lightweight vehicles. Woodhead Publishing; United Kingdom, 2020.

11) Hikku G, Jeyasubramanian K, Venugopal A, Ghosh R. Corrosion resistance behaviour of graphene/polyvinyl alcohol nanocomposite coating for aluminium-2219 alloy. J Alloys Compd. 2017;716:259–69. https://doi.org/10.1016/j.jallcom.2017.04.324

12) Nino A, Takahashi N, Sugiyama S, Taimatsu H. Effects of carbide grain growth inhibitors on the microstructures and mechanical properties of WC– SiC–Mo2C hard ceramics. Int J Refract Met Hard Mater. 2014;43:150–6. https://doi.org/10.1016/j.ijrmhm.2013.11.016

13) Loto RT, Babalola P. Corrosion resistance of low SiC particle variation at low weight content on 1060 alu minum matrix composite in sulfate-contaminated sea- water. Results Phys. 2019;13:102241. https://doi. org/10.1016/j.rinp.2019.102241

14) Hu Q, Zhao H, Li F. Microstructures and properties of SiC particles reinforced aluminum-matrix composites fabricated by vacuum-assisted high pressure die cast- ing. Mater Sci Eng A. 2017;680:270–7. https://doi. org/10.1016/j.msea.2016.10.090

15) Ramu I, Srinivas P, Vekatesh K, editors. Taguchi based grey relational analysis for optimization of machinng parameters of CNC turning steel 316. Interna- tional Conference on Mechanical, Materials and Renewable Energy; 2018. https://doi.org/10.1088/ 1757-899X/377/1/012078