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Experimental investigation of Aluminum alloy 6061 machining in Powder Mixed EDM

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Abstract

Powder mixed electric discharge machining process (PM-EDM) is a hybrid machining process uses conductive and non-conductive micron/nano powder particle in the dielectric medium. The aim of this article is to find the optimum machining parameter for PMEDM of Aluminum alloy 6061. The selected input process parameters are voltage, peak current, pulse on time, and concentration of SiC powder. Taguchi method L9 orthogonal array used to plan the experiment. Multi optimization genetic algorithm used to find the optimum value of input parameter which gives better surface finish.

Keywords: Powder mixed electric discharge machining process (PM-EDM), micron/nano powder, Aluminum alloy 6061

I. Introduction

The electrical discharge machining (EDM) well known advanced machining process used in many industries. but due to poor machining efficiency it is not used in full potential. To increase the efficiency and surface characteristic researchers have developed new powder mixed EDM process and the first publication came in 1981 by Erden and Bilgin [1]. Powder mixed EDM also term as Additive EDM. Adding suitable powder particles to the dielectric in the EDM process to improve the surface characteristics and material removal rate compare to the conventional EDM. In PMEDM powder particle in the dielectric reduce the electrical resistivity of the dielectric due to this breakdown take place at higher spark gap [2]. Due to increase in the spark gap proper flushing take place and intensity of the discharge energy reduce [3]. However, such expansion in the gap not occurs with every powder particle. It depends on thermo-physical property of powder particles such as density, electrical resistivity, and thermal conductivity, along with particle size and concentration [4-5]. However, to use powder mixed EDM extensively in industries it required through investigation of its mechanism and effect of different powder particles and dielectric on machining performance.

Aluminum alloy having multiple functional characteristics such as improved strength, high hardness, low weight, and good thermal and electrical conductivity [6]. Due to these properties, it is considered as high-tech engineering material and used in automobile, aerospace and many industries [7].

II. Process mechanism of PMEDM

The working mechanism of powder mixed EDM is different from conventional EDM. A series of voltage pulses applied between the electrodes. Typically, the gap between the electrodes is 10-200 micro meter [8]. Powder particle mixed in the dielectric fluid filled between the electrodes. Powder particles get energized due to the application of electric field. These energized particles experience a force of polarization which helps in the formation of bridge between the electrodes. Due to bridging the dielectric strength of the dielectric fluid decreases. This results in multiple discharge created within a single input pulse [9].

Experimentation-

Aluminum alloy 6061 used for machining in Powder mixed attached in electronica made for EDM S50 machine. Cu 99.9 % pure 12 mm diameter used as tool electrode. SiC micron powder (45-50µm) used in EDM oil dielectric.

Chemical composition of Al 6061

Chemical composition of Al 6061 Al- 97%, Mg- 1.2 %, Si- 0.8%, Fe- 0.6%, Cu- 0.4%

L9 orthogonal Taguchi method used to design the experiment. 4 level 3 factors used.

Table 1 Level of input parameters

Parameter	Low level	Medium level	High level
Peak current (Ip)	10	15	20
Pulse on time (Ton)	50	100	200
Voltage (V)	40	45	50
Conc. Of SiC (g/l)	8	10	12

Table 2Experimental results obtained for MRR, TWR, and surface roughness

Ip (A)	Ton (µs)	V (Volt)	Conc. (g/l)	MRR (mm^3/min)	TWR (mm^3/min)	Ra (µm)
10	50	40	8	146.8887	0.747767	2.561
10	100	45	10	134.5554	1.149552	2.896
10	200	50	12	170.3702	1.484373	2.661
15	50	45	12	154.2961	1.015624	3.753
15	100	50	8	180.222	1.037945	3.356
15	200	40	10	178.7035	1.294641	4.231
20	50	50	10	154.2961	1.316963	2.761
20	100	40	12	183.9257	1.462052	3.082
20	200	45	8	161.7035	1.629462	4.175

III. RESULTS AND DISCUSSION

Fig. 1, 2 , and 3 shows the clearly input parameter IP, V, Ton and conc. effect the MRR, TWR and Ra. In figure 1 initially by increasing the peak current MRR increases than decreases, similarly in case of voltage and by increasing the pulse on time MRR increase continuously and vice- versa in case of concentration. In figure 2 by increasing the current initially TWR increases than decreases and by increasing the Ton TWR increases continuously, and for increasing voltage and concentration initially increases with negative slope than decreases. From figure 3 it is clearly shown by increasing Ton, voltage and conc. SR increases and by increasing current initially it decreases than it increases.

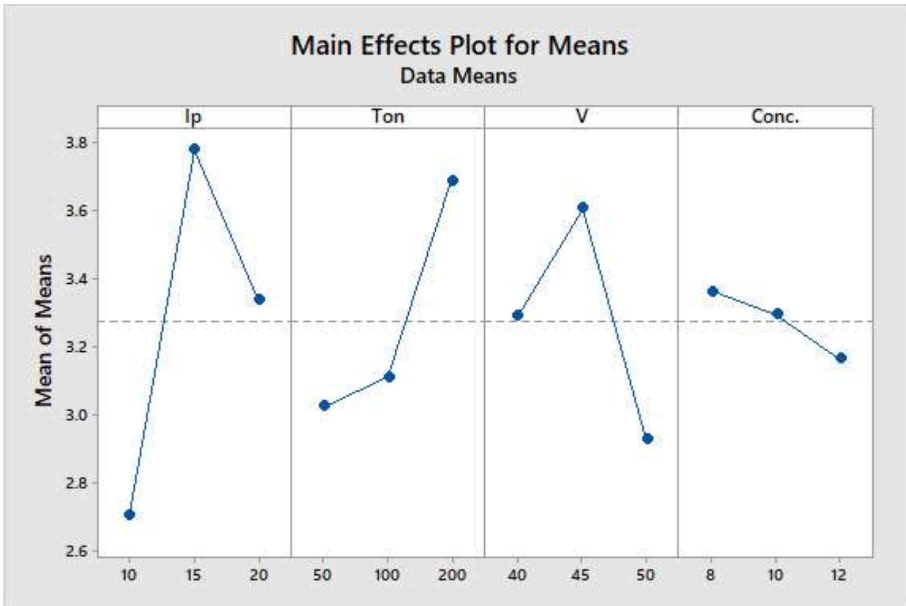

Fig. 1 Effect of Ip, Ton, V and Conc. On MRR

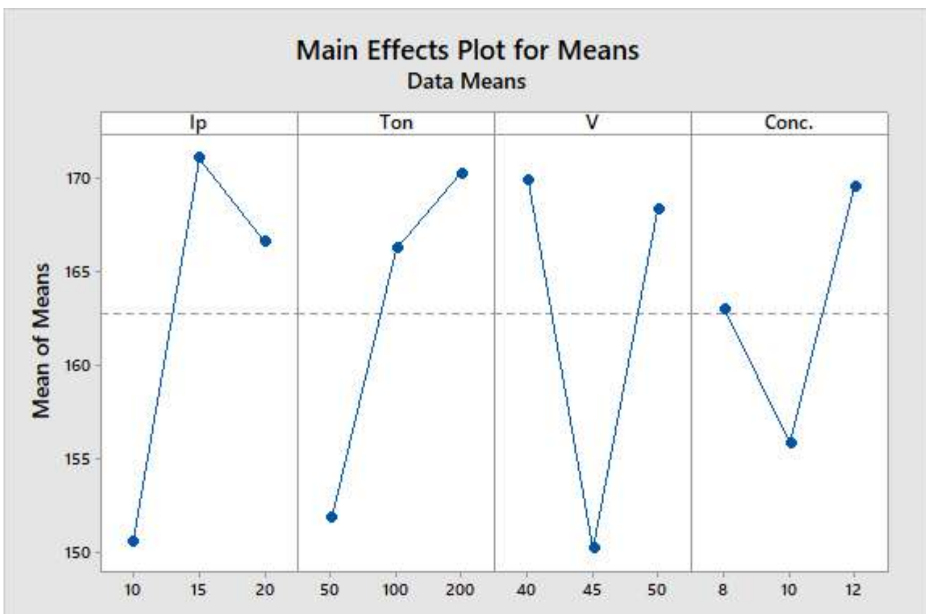

Fig. 2 Effect of Ip, Ton, V and Conc. On TWR

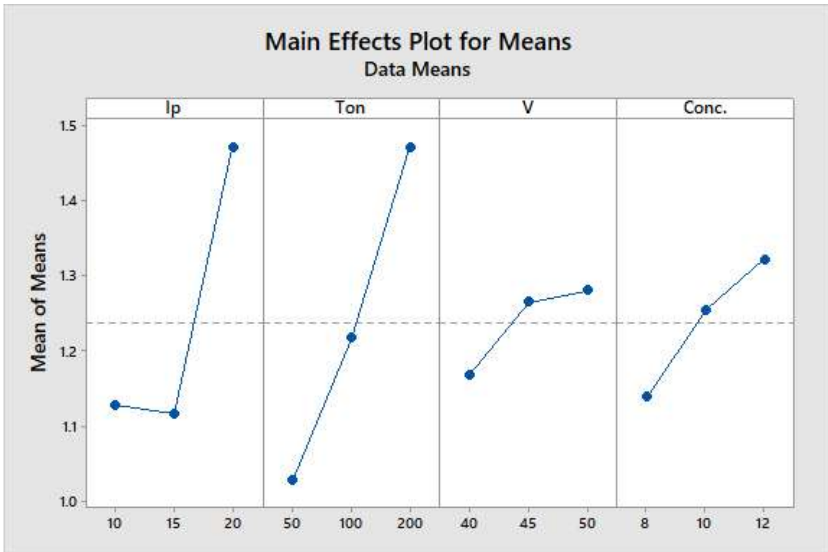

Fig. 3 Effect of Ip, Ton, V and Conc. on SR

Table 3 Process parameter and functional setting

Types of operation and parameter	Functions or parameters value used
Population a. Size, b. creation function	50 Constraint dependent
Selection	Tournament
Reproduction Crossover fraction	0.8
Crossover a. crossover function, b. crossover ratio	Single point 1.0
Mutation	Uniform
Generation	800
Functional tolerance	10^{-4}

Table 4 Pareto optimal solution

Index	f1	f2	f3	x1	x2	x3	x4
1	150.6668	1.111021	2.007425	10	50	49.98913	11.99425
25	150.6668	1.111021	2.007425	10	50	49.98913	11.99425
17	149.124	1.11065	2.057727	10	50	49.77159	11.99425
23	143.0789	1.081623	2.065059	10	50	50	11.18712
3	139.9348	1.065312	2.099243	10	50	49.98913	10.69618
18	137.9318	1.024349	2.170451	10	50	49.98913	9.25
15	136.3892	1.023979	2.220752	10	50.00025	49.77159	9.25
14	135.8334	1.042733	2.445928	10.36914	50	48.98913	10.69618
19	139.3965	0.994913	2.508679	10	50.00055	40	9.778212
13	146.6023	0.954222	2.566038	10	50.00074	40	8
10	132.8645	1.004067	2.652513	10	51.00006	41	9.778212
11	133.7481	0.982201	2.683357	10	50.13159	41	9
2	119.7906	1.021582	2.82472	10	50	45.13931	9.69618

22	121.8588	0.995354	2.924931	10.18032	50	44.77903	9.137135
16	151.3858	0.894076	3.087677	11.36914	50.50074	40.5	8
20	125.9919	0.971063	3.16073	11	50	45.13931	9.69618
12	128.026	0.956791	3.269457	11.36914	50	45.13931	9.69618
5	147.9462	0.914838	3.334725	13.41758	50	48.77159	9
7	156.4198	0.893818	3.406756	13.41758	50.00006	40	9.778212
9	163.6255	0.853127	3.464116	13.41758	50	40	8
6	158.0468	0.869785	3.601955	13.91758	50.50074	40.5	8.5
8	161.6758	0.859948	3.613077	13.91758	50.50074	40.5	8
24	144.6067	0.875739	3.71398	12.9769	50	43.44589	8
4	142.85	0.887248	3.810245	13.66758	50.00659	45.11587	8.25
21	141.3308	0.926434	3.833097	14.66758	50.00659	46.11587	9.25

f1=MRR, f2= TWR, and f3= SR,

x1= peak current, x2= pulse on time, x3=voltage, and x4 = conc.

Table 5 Confirmation test

Optimal combination				Model predicted			Experimental			Prediction Error (%)		
Ip(A)	Ton (μs)	Voltage (V)	Conc. (g/l)	MRR (mm^3/min)	TWR (mm^3/min)	Ra (μm)	MRR (mm^3/min)	TWR (mm^3/min)	Ra (μm)	MRR (mm^3/min)	TWR (mm^3/min)	Ra (μm)
10	50	50	12	150.152	1.11089	2.0241	154.9568	1.1741	2.2163	3.2	5.7	9.5

The error is less than 10% so optimum parameter determine by Multi objective genetic algorithm (GA)can be considered as optimum process parameter for machining of Al 6061 alloy.

IV. CONCLUSION

In this study Multi objective genetic algorithm based on orthogonal experimental design us used to determine the optimum machining parameter. The values are Ip 10A, Ton 50μs, voltage 50V and conc. 12g/l give MRR 150.152 mm3/min, TWR 1.11089 mm3/min, and surface roughness 2.0241. This study shows the combined application of Taguchi and GA for finding successfully optimum parameter in multiple performances.

REFERENCES

[1] A. Erden and S. Bilgin, "Role of Impurities in Electric Discharge Machining.," *Proc. Int. Mach. Tool Des. Res. Conf.*, no. 4, pp. 345–350, 1981.

[2] M. P. Jahan, M. Rahman, and Y. S. Wong, "Study on the nano-powder-mixed sinking and milling micro-EDM of WC-Co," *Int. J. Adv. Manuf. Technol.*, vol. 53, no. 1–4, pp. 167–180, 2011.

[3] H. M. Chow, L. D. Yang, C. T. Lin, and Y. F. Chen, "The use of SiC powder in water as dielectric for micro-slit EDM machining," *J. Mater. Process. Technol.*, vol. 195, no. 1–3, pp. 160–170, 2008.

[4] T. Yih-Fong and C. Fu-Chen, "Investigation into some surface characteristics of electrical discharge machined SKD-11 using powder-suspension dielectric oil," *J. Mater. Process. Technol.*, vol. 170, no. 1–2, pp. 385–391, 2005.

[5] G. Talla, S. Gangopadhayay, and C. K. Biswas, "State of the art in powder-mixed electric discharge machining: A review," *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, vol. 231, no. 14, pp. 2511–2526, 2017.

[6] S. Singh and M. F. Yeh, “Optimization of abrasive powder mixed EDM of aluminum matrix composites with multiple responses using gray relational analysis,” *J. Mater. Eng. Perform.*, vol. 21, no. 4, pp. 481–491, 2012.
[7] P. Pecas and E. Henriques, “Influence of silicon powder-mixed dielectric on conventional electrical discharge machining,” *Int J Mach Tools Manuf*, vol. 43, 2003.
[8] H. K. Kansal, S. Singh, and P. Kumar, “Effect of silicon powder mixed EDM on machining rate of AISI D2 die steel,” *J. Manuf. Process.*, vol. 9, no. 1, pp. 13–22, 2007.
[9] W. S. Zhao, Q. G. Meng, and Z. L. Wang, “The application of research on powder mixed EDM in rough machining,” in *Journal of Materials Processing Technology*, 2002, vol. 129, no. 1–3, pp. 30–33.