International Journal of Current Engineering and Technology
©2015 INPRESSCO®, All Rights Reserved
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

EDM of Heat Treated-Al 7075

Rahul Rawat[†*] and Vishal Kumar[†]

[†]Mechanical Engineering Department, Modern Institute of Engineering and Technology (Mohri), Kurukshetra, India

Accepted 13 Sept 2015, Available online 14 Sept 2015, **Vol.5, No.5 (Oct 2015)**

Abstract

In this paper the electric discharge machining of heat treated AA-7075 were carried and tool wear rate was investigated. Pulse on-time, pulse off-time, servo voltage and peak current were the input process parameters. Experiments were conducted according to central composite design. Pulse on-time had the maximum contribution on tool wear rate followed by pulse off-time and servo voltage.

Keywords: *EDM, AA 7075, CCD, TWR.*

1. Introduction

Electrical Discharge Machine (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. Following paragraphs describe researches carried on EDM:

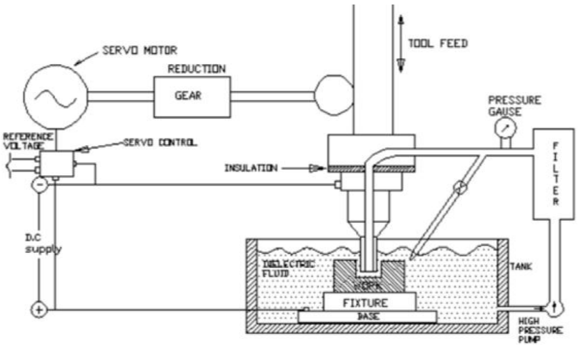

Figure 1: Working principle of EDM Process

Patel *et al.* (2009) developed ceramic composite material (Al2O3–SiCw–TiC) and selected to investigate its EDM machinability. The recent developments in ceramic composites are focused not only on the improvements of strength and toughness, but also on possibilities for difficult-to-machine shapes using EDM.

Yu *et al.* (2009) said that when a micro-hole is drilled deeply by EDM, the viscous resistance in the narrow discharge gap causes difficulty in the removal of debris and bubbles from the working area, leading to frequent occurrences of abnormal discharges and resulting in extensive electrode wear.

Chern *et al.* (2007) studied burr formation in micro-machining using micro-tools. The micro-tools employed are fabricated by micro-EDM using the wire electro-discharge grinding (WEDG) method in the micro-EDM/milling machine we had already developed. Micro tungsten-carbide tool with a minimum of 31µm in diameter had been fabricated.

Abbas *et al.* (2006) analysed that Electrical discharge machining (EDM) is one of the earliest non-traditional machining processes. EDM process is based on thermoelectric energy between the work piece and an electrode. A pulse discharge occurs in a small gap between the work piece and the electrode and removes the unwanted material from the parent metal through melting and vaporising.

Guu and Hou (2007) analysed **s**urface characteristics caused by EDM by means of the atomic force microscopy (AFM) technique. An empirical model of Fe-Mn-Al alloy was proposed based on the experimental data. A qualitative energy dispersive spectroscopic analyzer was used to measure the chemical composition of the specimen. Surface hardness was determined with a micro hardness tester.

Jeong and Min (2007) proposed Geometric simulation model of EDM drilling process with cylindrical tool to predict the geometries of tool and drilled hole. The geometries of tool and workpiece are represented by two dimensional matrixes. For accurate prediction of their geometries, the tool motion, the sparking gap width, the spark frequency, the crater made by a single spark, and the tool wear ratio are considered as simulation parameters.

Taweel (2008) studied relationship of process parameters in electro-discharge of CK45 steel with novel tool electrode material such as Al–Cu–Si–TiC composite produced using powder metallurgy (P/M) technique. The central composite second-order rotatable design had been utilized to plan the

*Corresponding author: **Rahul Rawat**

experiments, and response surface methodology (RSM) was employed for developing experimental models. Analysis on machining characteristics of electrical discharge machining (EDM) die sinking was made based on the developed models. In this study, titanium carbide percent (TiC%), peak current, dielectric flushing pressure, and pulse on-time are considered as input process parameters.

A number of researchers **(Gupta *et al.*, 2012; Sharma *et al.* , 2011, 2013a; 2013b; 2014a; 2014b; 2014c; 2015; Kumar *et al.* (2014), Khanna *et al.*, 2015)** utilized planning of experimentation to reduce the experiments and analysis the process parameters. In the present research electric discharge machining of heat treated aero-space alloy AA 7075 was considered and metal removal rate was investigated.

Table 1: Process parameters, units and its Range

S.No.	Process Parameters	Notation	Unit	Range
1	Pulse on-time	Ton	µs	130-170
2	Pulse off-time	Toff	µs	30-45
3	Peak Current	IP	A	2-5
4	Servo voltage	SV	V	30-50

2. Experimentations

The experiments were carried out on EDM machine (ELEKTRA PLUS R50) of Electronica Machine Tools Ltd.

Design: Fixed column, moving table
Table size: 500 x 300 mm
Max. Height above the table: 250 mm
Max. permitted load on table: 175 kg
Max. electrode weight: 50 kg
Weight is measured by the Mitutoyo make high precision weight balance with least count 0.001g.

Tool wear rate was calculated by below mentioned formula

Tool Wear rate = (Initial weight – Final Weight)/ (Time taken)
The range of process parameters is given in Table 1.

2. Results and discussions

Table 2 represent the design matrix for four parameters and corresponding values of MRR. Experiments are performed according to run order.

Table 2: Design Matrix and Responses

Std	Run	A:Ton (us)	B:Toff (us)	C:IP (A)	D:SV (V)	MRR (mg/min)
5	1	170	30	2	50	0.0977
13	2	150	37.5	0.98	40	0.0559
16	3	150	37.5	3.5	56.82	0.0907
1	4	170	45	5	30	0.0669
9	5	116.36	37.5	3.5	40	0.0521
7	6	130	45	5	50	0.05293
17	7	150	37.5	3.5	40	0.0807
19	8	150	37.5	3.5	40	0.0865
3	9	170	30	5	50	0.0593
18	10	150	37.5	3.5	40	0.0881
21	11	150	37.5	3.5	40	0.0893
20	12	150	37.5	3.5	40	0.0879
4	13	130	45	2	50	0.0403
2	14	170	45	2	30	0.0863
12	15	150	50.11	3.5	40	0.0878
15	16	150	37.5	3.5	23.18	0.0623
8	17	130	30	2	30	0.0299
10	18	183.64	37.5	3.5	40	0.1171
6	19	130	30	5	30	0.0789
11	20	150	24.89	3.5	40	0.0311
14	21	150	37.5	6.02	40	0.0752

The analysis of response data is done by well-known software Design Expert specifically used for the design of experiment applications.

3.1 Analysis of Tool Wear Rate (TWR)

Table 3 shows the ANOVA for TWR during the experimentation of EDM. Quadratic model is significant and lack of fit is non-significant. Pulse-on time, off-time and servo voltage are significant factors along with interaction and quadratic parameters of off-time, servo voltage and Peak current.

The Model F-value of 27.10 implies the model is significant. There is only a 0.01% chance that a Model F-Value this large could occur due to noise. Values of Prob > F less than 0.0500 indicate model terms are

Table 3 Analysis of Variance for TWR

Source	SS	df	MS	F-Value	p-value	
Model	0.01	14	7.33E-04	31.03	0.0002	**significant**
A-Ton	2.11E-03	1	2.11E-03	89.42	< 0.0001	
B-Toff	1.61E-03	1	1.61E-03	68.04	0.0002	
C-IP	9.64E-05	1	9.64E-05	4.08	0.0899	
D-SV	4.03E-04	1	4.03E-04	17.07	0.0061	
AB	3.26E-04	1	3.26E-04	13.79	0.0099	
AC	1.78E-03	1	1.78E-03	75.47	0.0001	
AD	1.23E-03	1	1.23E-03	52.13	0.0004	
BC	3.77E-05	1	3.77E-05	1.6	0.2533	
BD	1.12E-04	1	1.12E-04	4.72	0.0727	
CD	3.83E-04	1	3.83E-04	16.22	0.0069	
A^2	1.38E-05	1	1.38E-05	0.59	0.4733	
B^2	1.45E-03	1	1.45E-03	61.42	0.0002	
C^2	8.85E-04	1	8.85E-04	37.48	0.0009	
D^2	2.19E-04	1	2.19E-04	9.26	0.0227	
Residual	1.42E-04	6	2.36E-05			
Lack of Fit	9.57E-05	2	4.79E-05	4.16	0.1053	**not significant**
Pure Error	4.60E-05	4	1.15E-05			
Cor Total	0.01	20				

significant. In this case A, B, D, AB, AC, AD, CD, B2, C2, D2 are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model. The Lack of Fit F-value of 4.50 implies there is a 8.50% chance that a Lack of Fit F-value this large could occur due to noise. Lack of fit is bad we want the model to fit. This relatively low probabiity (<10%) is troubling.

Figure 2 and Figure 3 represent the normal plot of residual and predicted vs actual. In both figures residuals falls on a straight line, which verifies the ANOVA test.

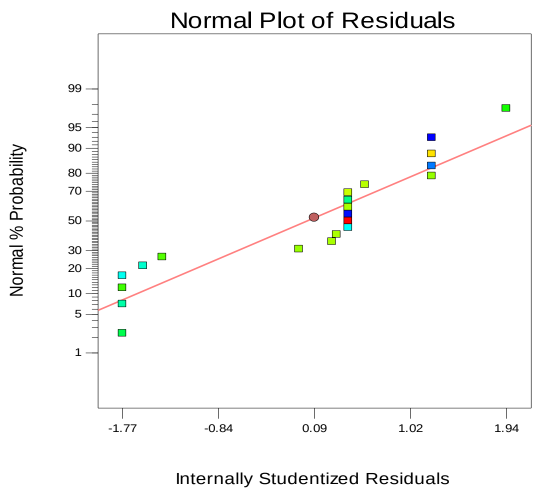

Figure 2: Normal Plot of Residuals (TWR)

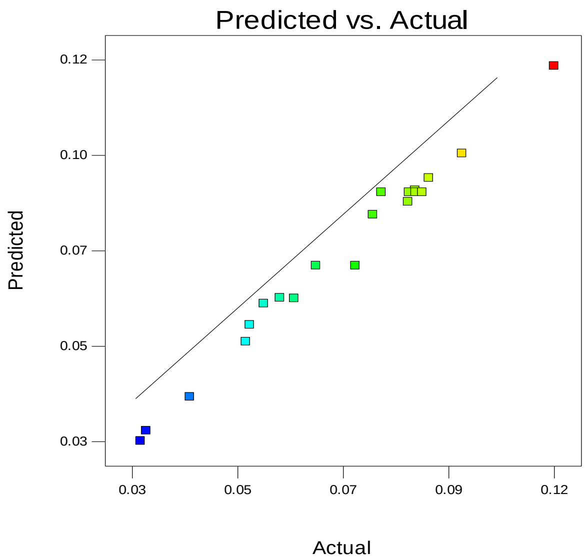

Figure 3: Predicted Vs Actual (TWR)

Table 4: Predicted optimal value of TWR

Responses	TWR
Optimized Setting	$A_{130}B_{30}C_{3}D_{49}$
Predicted Value	0.0289
Actual Value	0.031

From Table 4 it is revealed that at optimized setting confirmations experiments present excellent results reproducibility.

Conclusions

Following Conclusion comes into picture after this research work

1. Tool wear rate increase with the increase of pulse on time and peak current.
2. TWR decreases with increase of pulse off time and servo-voltage.
3. A strong interaction between pulse-on time and peak current; pulse on time and servo voltage is observed.

References

Guu YN, Hou Max Ti-Kuang. (2007), Effect of machining parameters on surface textures in EDM of Fe-Mn-Al alloy, Materials Science and Engineering, 466, 2007, pp. 61-67.

Abbas N. M, Solomon D. G, Bahari Md. Fuad (2007), A review on current research trends in electrical discharge machining, International Journal of Machine Tools and Manufacture, volume. 47, pp. 1214-1228.

Chern, G. L and Wu Y.J, Cheng J, Yao J.c (2007), Study on burr formation in micro-machining using micro-tools fabricated by micro-EDM, Precision Engineering, vol. 31, pp. 122–129.

Patel K.M., Pandey P.M., Rao P.V. (2010). Optimization of process parameters for multi-performance characteristics in EDM of Al_2O_3 ceramic composite, Int J Adv Manuf Techno, Vol. 47, pp.1137–1147.

Yu Z.Y, Zhang Y, Li J, Luan j, Zhao F, Guo D(2009), High aspect ratio micro-hole drilling aided with ultrasonic vibration and planetary movement of electrode by micro-EDM, CIRP Annals - Manufacturing Technology, vol 58 pp 213-216.

Young Hun Jeong, Byung-Kwon Min(2007), Geometry prediction of EDM-drilled holes and tool electrode shapes of micro-EDM process using simulation, International Journal of Machine Tools and Manufacture , Volume 47 (12), pp 1817-1826.

T. A. El-Taweel, Multi-response optimization of EDM with Al–Cu–Si–TiC P/M composite electrode, The International Journal of Advanced Manufacturing Technology. September 2009, Volume 44, Issue 1, pp 100-113

Pardeep Gupta, Rajesh Khanna, R D Gupta, Neeraj Sharma (2012) Effect of Process Parameters on Kerf Width in WEDM for HSLA Using Response Surface Methodology, Journal of Engineering Technology (Wolters Kluwer Publications), Vol. 2(1), pp. 1-6.

Neeraj Sharma, Rajesh Khanna (2011), Optimization of process parameters of cryogenic treated D-3 in WEDM by Taguchi Approach, International Journal of Engineering Research and Applications, Vol. 1(3), pp.546-553.

Neeraj Sharma, Rajesh Khanna, Rahuldev Gupta, Renu Sharma (2013a), Modelling and Multi Response Optimization on WEDM for HSLA by RSM, International Journal of Advanced Manufacturing Technology, Vol. 67, pp. 2269–2281. DOI 10.1007/s00170-012-4648-4.

Neeraj Sharma, Rajesh Khanna, Rahul dev Gupta (2013b), Multi Response Optimization of WEDM Process Parameters with RSM, Procedia Engineering, Vol. 64, pp.710-719.

Neeraj Sharma, Ajit Singh, Renu Sharma, Deepak (2014a), Modelling the WEDM Process Parameters for Cryogenic Treated D-2 Tool Steel by integrated RSM and GA, Journal of Procedia Engineering, Vol. 97, pp. 1609-1617.

Neeraj Sharma, Neeraj Ahuja, Sorabh Gupta, Ajit Singh, Renu Sharma (2014b), Modeling and Parametric Investigation of WEDM for D-2 Tool Steel Using RSM and GA, Applied Mechanics and Materials, Vol. 592-594, pp 511-515.

Neeraj Sharma, Tilak Raj, Kamal K Jangra (2014c) Parameter Optimization and Experimental Study on Wire Electrical Discharge Machining of Porous $Ni_{40}Ti_{60}$ alloy, Proc. IMechE Part B: Journal of Engineering Manufacture. doi:10.1177/ 0954405415577710.

Neeraj Sharma, Rajesh Khanna, Rahul Dev Gupta (2015) WEDM Process Variables Investigation for HSLA by Response Surface Methodology and Genetic Algorithm, Engineering Science and Technology: an International Journal, Vol. 18 (2), pp. 171-177. doi:10.1016/j.jestch.2014.11.004.

Kamal Kumar Jangra, Neeraj Sharma, Rajesh Khanna, Deepak (2014) An Experimental Investigation and Optimization of Friction Stir Welding process for AA6082 T6 (cryogenic treated and untreated) using an integrated approach of Taguchi, GRA and Entropy Method, Proc. of IMeche Part L: Part L: Journal of Materials: Design and Applications. DOI: 10.1177/1464420715578182