

Experimental Study of MRR, TWR, SR on AISI D2 Steel using Aluminium Electrode on EDM

Sidhant Gupta¹, Dr. S.K. Jain² and Gurpinder Singh³

¹ Ambala College of Engineering and Applied Research

Received: 9 December 2016 Accepted: 31 December 2016 Published: 15 January 2017

Abstract

This paper depicts the experimental study of the input parameters of EDM i.e. current, pulse on time and pulse off time on output parameters material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The workpiece materials selected was AISI D2. The aluminium used as tool electrode and EDM oil as dielectric fluid. Taguchi, method was used to perform experiments, L9 orthogonal array was applied using MINITAB software. Signal to Noise (S/N) ratio and ANOVA were employed for parameter optimization and to achieve max MRR, min SR and TWR. The results indicate that the most prompting factor for MRR is Pulse off time. For TWR, the most influencing factor is current. For SR, the most prompting factor is pulse on time. Optimization is done by using Taguchi method on MINITAB 17 software

Index terms— electric discharge machine, aluminium electrode, ss316, aisi d2 steel, minitab.

1 I. Introduction

lectric Discharge Machine (EDM) is a nontraditional machining process. It has number of applications in die making, punches and molds industry. It also finds application in manufacturing of finished parts in automobile, also in manufacturing of surgical components. In EDM, electric spark is produced between workpiece and electrode and due to this spark material gets eroded from workpiece and tool electrode [1]. So this process can be successfully employed to materials which are electrically conductive. Hardness, shape, toughness and brittleness don't cause any restrictions [2]. In die sinking EDM, the shape which is to be produced on workpiece, the tool should be replica of that shape. Both tool electrode and workpiece are dipped in a dielectric fluid like EDM oil, Kerosene etc. The workpiece and electrode are placed at a very close distance and it depends on operating conditions and called as spark gap [3]. Modern era of EDM, i.e. from 1995 to till date. Many new aspects has been developed, namely micro-machining by EDM and dry EDM i.e. EDM without dielectric fluid. Now a days EDM is most acceptable technique for MRR [3]. For micro machining, ultrasonic vibration method is apt, dry machining is economical and water EDM is safe and conductive working environment, Powder mixed EDM is concerned more on improving surface quality [4]. The viability of machining Tungsten carbide ceramics by EDM with a graphite electrode using Taguchi method is studied and concluded that the current mainly effects the EWR and SR. The pulse duration is the most influencing factor for MRR [5]. For machining of tungsten carbide, graphite electrode gives the maximum MRR with comparison to copper and copper tungsten electrode [6]. The study of MRR by copper and graphite electrodes of different diameter is performed on XW42 tool steel. Copper is apt for roughing process, while graphite electrode is apt for finishing [7]. Copper, copper alloys and graphite has a problem of low wear resistance. A new composite ZrB₂-Cu is developed to get an ideal combination of wear resistance, electrical and thermal conductivity. This composite demonstrates more MRR with less TWR than copper tool [8]. When manufacturing deep slots in low machinability materials, EDM may be the only method [9]. Investigation is done on SS 316L using compressed air as dielectric and copper electrode as tool [10]. MRR is primarily influenced by peak current and EWR is primarily influenced by peak current trailed by pulse on

time [11]. For MRR, using copper as electrode input current & duty cycle is more dominant. Pulse on time and duty cycle for EWR, duty cycle and pressure for surface roughness [12]. EDM parameters using grey relational analysis on AISI SS (202), parameters mainly discharge current, and pulse off time and pulse on time [13]. The effect of abrasive mixed dielectric on AISI D3steel is studied. At 6 g/ltr of concentration MRR is maximum. EDM (Abrasive mixed) outcomes in 58% more MRR as compared to traditional EDM [14]. Experiments were performed to determine factors effecting SR using brass, copper and aluminium as electrodes on Mild steel [15]. Aluminium yielded highest MRR followed by copper.

For present work, studies are conducted on AISI D2 steel using aluminium electrode to determine the MRR, TWR and SR and optimum values are predicted using MINITAB 17.

2 II. Workpiece and Electrode Material

AISI D2 steel is used mainly in die and mould making industry. Now a days dies are of very complicated shape so to achieve that kind of shape, non-conventional machining methods are employed because it cannot be achieved by conventional methods.

Abstract-This paper depicts the experimental study of the input parameters of EDM i.e. current, pulse on time and pulse off time on output parameters material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The workpiece materials selected was AISI D2. The aluminium used as tool electrode and EDM oil as dielectric fluid. Taguchi, method was used to perform experiments, L 9 orthogonal array was applied using MINITAB software. Signal to Noise (S/N) ratio and ANOVA were employed for parameter optimization and to achieve max MRR, min SR and TWR. The results indicate that the most prompting factor for MRR is Pulse off time. For TWR, the most influencing factor is current. For SR, the most prompting factor is pulse on time. Optimization is done by using Taguchi method on MINITAB 17 software. Aluminium is silvery white, soft, non-magnetic, ductile material. Aluminium and its alloys are vital to aerospace industry. Aluminium is capable of super conductivity. Aluminium find its application in electrical transmission lines for the purpose of power transmission. Melting point of aluminium is 933.47 K and density 2.70 g/cm³, electrical conductivity 3.50×10⁷ S/m.

3 c) Signal to noise (S/N) ratio

The main objective of the study is to examine the effect of aluminium as electrode on AISI D2 steel. Signal to Noise (S/N) ratio is selected as larger is better for MRR, smaller the better for SR and TWR. S/N ratios are defined as: Larger is better = $-10 \log (\text{MSDHB})$ Where $\text{MSDHB} = 1/r^2 = ()$, r = the number of tests in a trial y_i = observed value of response characteristics For Tool wear rate (TWR) the S/N ratio is smaller is better. Where $\text{MSDLB} = \text{Mean Square deviation for smaller the better response}$.

4 d) Design of Experiments

Experiments In present study, Taguchi method was used to design the experiments. For optimization of system, Taguchi Technique reduces the trial of experiments to get only the necessary trial of experiments so there will be no repeated trials and it's done using DOE. Three parameters viz., pulse on, current and pulse off were chosen as control parameters and apiece parameter has three levels shown in table 2. L 9 orthogonal array was used to design the experiments shown in table 3. To obtain accurate results, each experiment was performed three times and there mean value is taken for optimization. Table ?? showing the values of material removal rate, tool wear and Surface roughness. MRR and TWR are measured in grams. SR is measured in microns using surface roughness tester. Experiments were executed three times to get the accurate results. For S/N ratio we always take maximum value irrespective of smaller the better or larger is better. For mean of means, we select maximum values for optimization if S/N is higher the better and we take minimum value if it is smaller is better. Graph displayed in figure 6 is made using table 6. For SR, S/N ratio is smaller the better. So for SN ratio graph we take maximum values and for means we take

5 Table 3: Observation Table

6 V. Conclusion

The main motive of the present study was to experimentally inspect the effect of aluminium as electrode which is tool on MRR, TWR and SR on AISI D2 steel. Optimum conditions for the output parameters are. 1. The Optimum conditions for MRR is Current (10 A), Pulse on (100 μ s), Pulse off (10 μ s) for AISI D2 steel. 2. For TWR, the most prompting factor is pulse off time, followed by current and then pulse on time.

The optimum condition for TWR is Current (6A), Pulse on (150 μ s), Pulse off (6 μ s) for AISI D2 steel. 3. For SR, pulse on time is the most prompting factor followed by current and pulse off time. The optimum condition for SR is current (6A), Pulse on (50 μ s), Pulse off (8 μ s) for AISI D2 steel.



Figure 1:



1

Figure 2: Figure 1 :

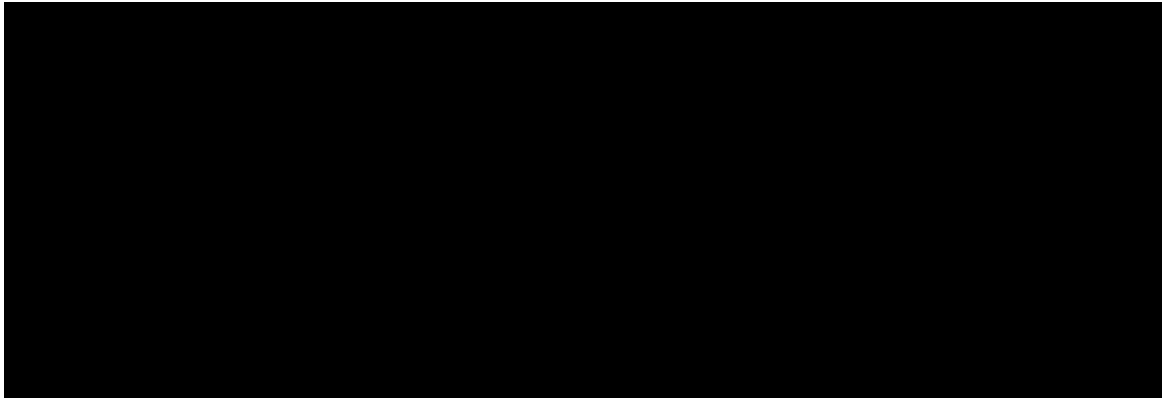
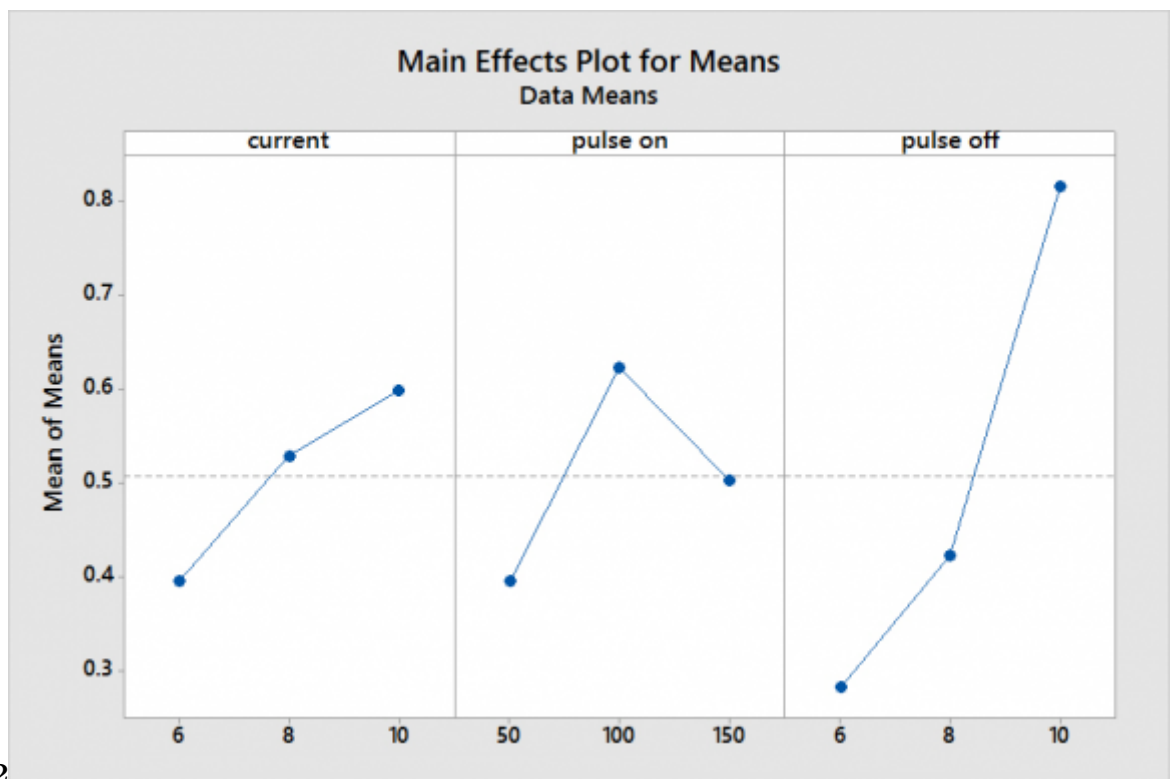
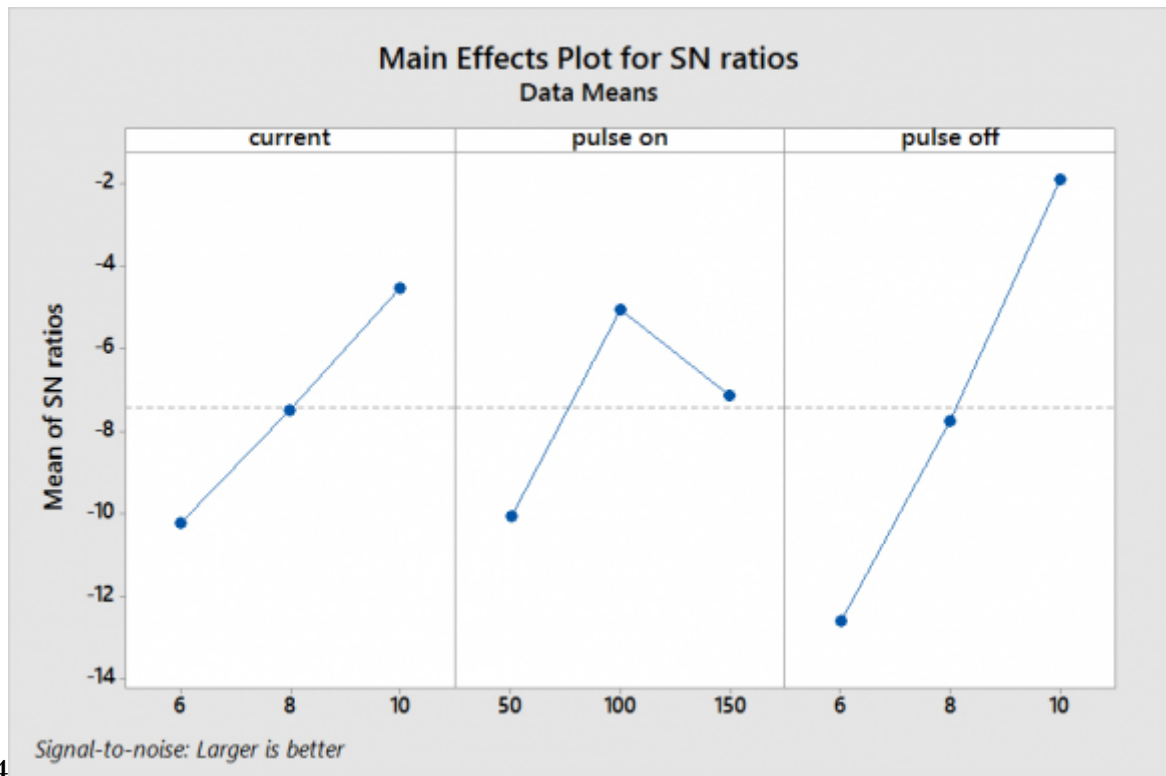


Figure 3:



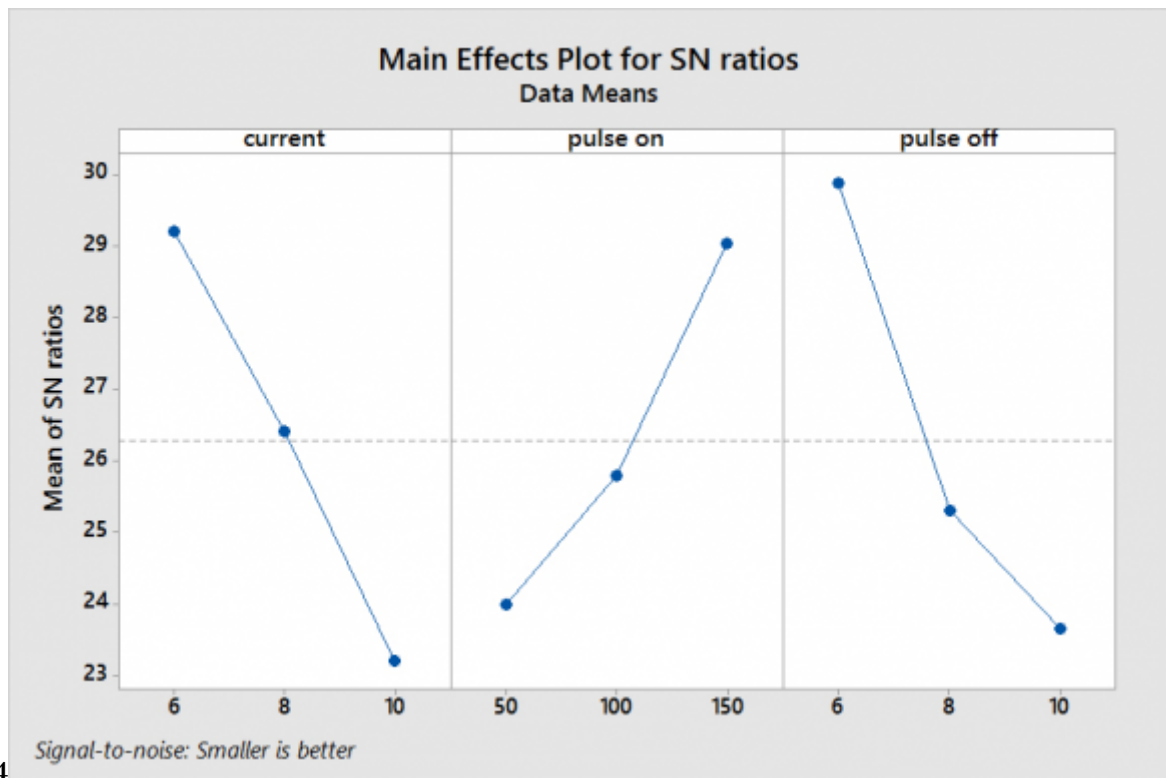
20172

Figure 4: Year 2017 A 2 :



4

Figure 5: Figure 4 ,



4

Figure 6: Figure 4 :

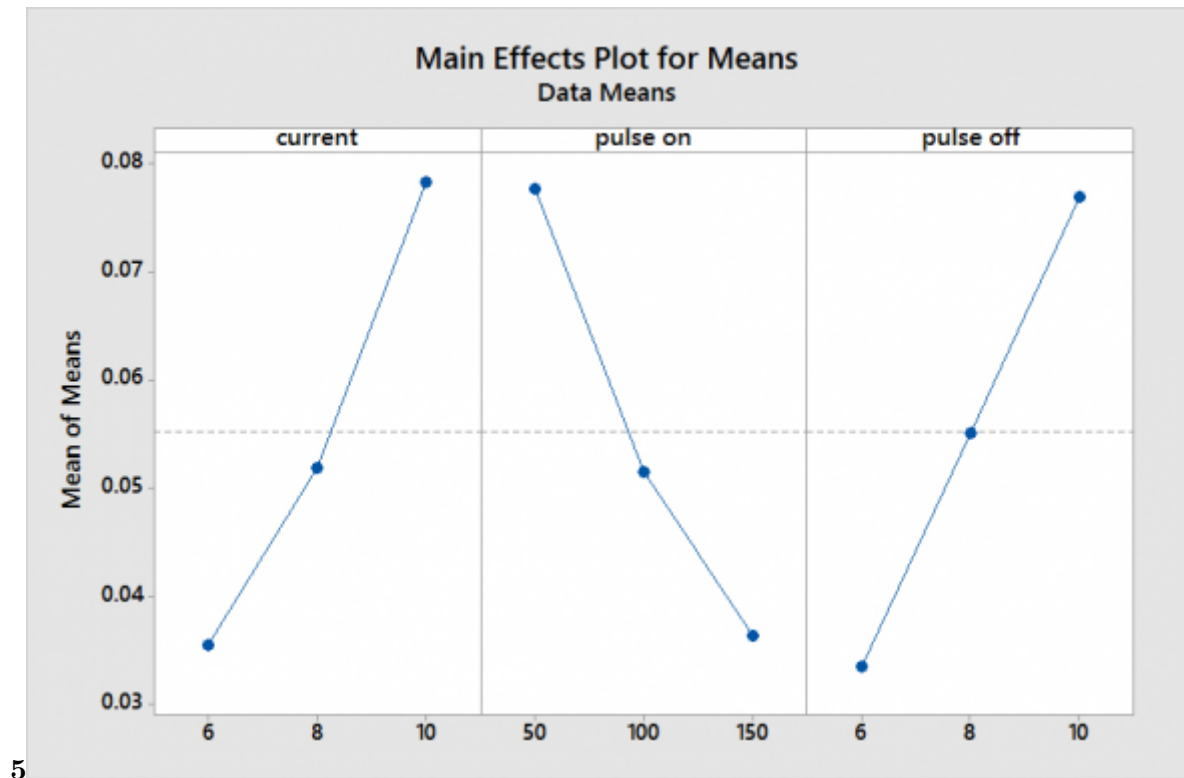


Figure 7: Figure 5 :

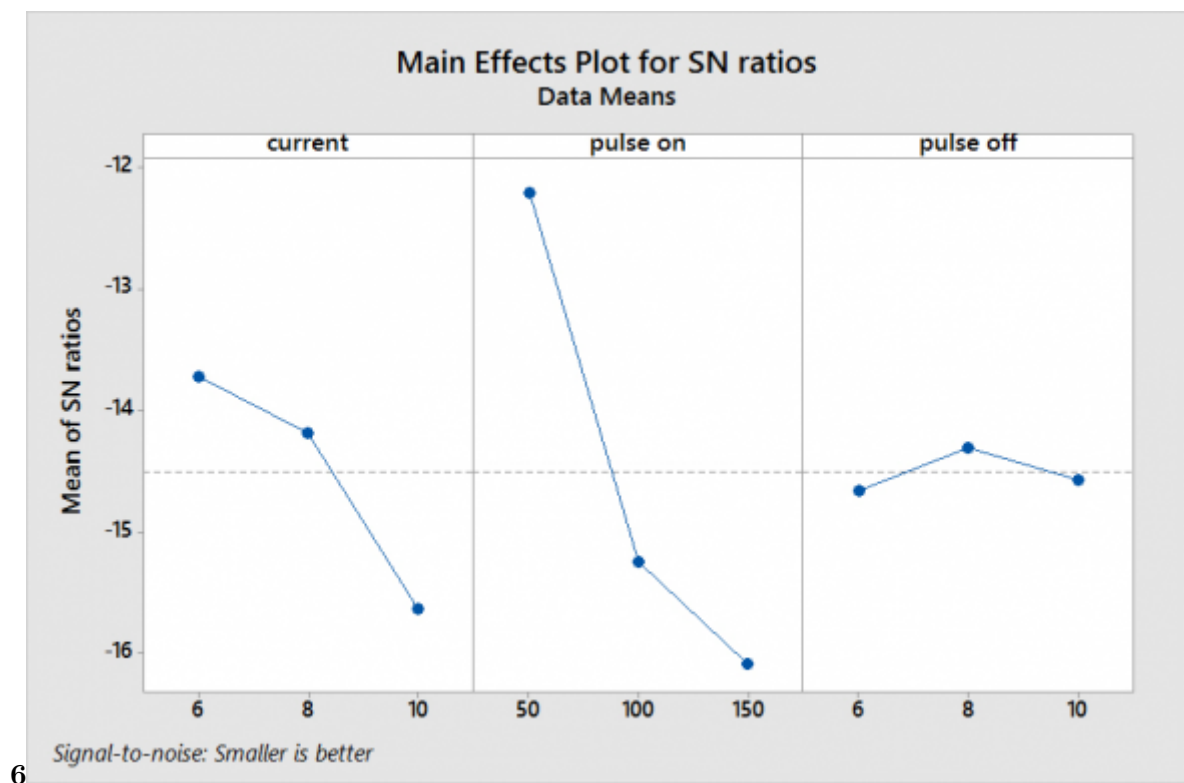


Figure 8: Figure 6 :

1

Composition of AISI D2									
C	Mn	Si	Cr	Ni	Mo	P	S	Fe	
2.11%	0.3531%	0.48%	12.88%	0.1547%	0.4312%	0.0181%	0.0127%	Balance	

Figure 9: Table 1 :

4

Serial No	Current Ip, A	Pulse on Ton, μ s	Pulse off Toff, μ s	Material removed							Tool		
				MRR1	MRR2	MRR3	TWR1	TWR2	TWR3	SR1			
1	6	50	6	0.1195	0.1232	0.1211	0.0268	0.0234	0.0274	4.534	4.243	4.0	
2	6	100	8	0.3411	0.3144	0.3356	0.0411	0.0489	0.0477	5.133	5.698	5.0	
3	6	150	10	0.72	0.7329	0.7469	0.03	0.0392	0.0342	6.149	5.745	6.253	
4	8	50	8	0.36	0.3713	0.3675	0.0769	0.0648	0.0698	4.378	4.135	4.0	
5	8	100	10	1.0166	1.0087	1.021	0.06	0.0567	0.0622	7.297	7.546	7.06	
6	8	150	6	0.2031	0.1967	0.2104	0.0269	0.0212	0.0287	6.488	6.143	6.0	
7	10	50	10	0.7	0.6934	0.7062	0.133	0.1411	0.1369	6.045	6.316	6.431	
8	10	100	6	0.5166	0.5251	0.5286	0.05	0.0478	0.0493	6.618	6.754	6.5	
9	10	150	8	0.57	0.5772	0.5658	0.05	0.0478	0.0493	7.661	7.211	7.521	
S.no	SNRA1	MRR	MEAN1	SNRA1/TWR							MEAN1		
1	-18.3271998	0.12126667	31.72510106	0.02586667	-11.0588253								
2	-9.63634552	0.33036667	26.73957182								0.04		
3	-2.69768287	0.73326667	29.20061811	0.03446667	-15.3648633								
4	-8.72620694	0.36626667	23.01473492								0.07		
5	0.13270037	1.01543333	24.48398351	0.05963333	-14.4654947							5.2876667	
6	-13.8428249			0.2034								31.76799737	0.02
7	-3.10042071	0.69986667										17.263058	0.13
8	-5.62398705	0.52343333	26.18865056	0.04903333	-16.5331788							6.7086667	
9	-4.86816042			0.571								26.18865056	0.0490

Figure 10: Table 4 :

4

() Volume XVII Issue I Version I
 Journal of Researches in Engineering
 Global

Figure 11: Table 4

7

Figure 12: Table 7 :

for

	Response Table for MRR	
Response table for S/N ratio	Response table for Means	Response table for S/N ratio
		Level Current Pulse On Pulse off Curr
1 -10.22 -10.051 -12.598 0.39 0.3958 0.2827		1 -13.72 -12.21 -14.66 4.961 4.117 5.62
2 -7.479 -5.043 -7.744 0.5284 0.6231 0.4225		2 -14.18 -15.24 -14.31 5.241 5.814 5.32
3 -4.531 -7.136 -1.888 0.5981 0.5026 0.8162		3 -15.63 -16.08 -14.57 6.11 6.38 5.363
Delta 5.69 5.009 10710 0.2031 0.2273 0.5335		Delta 1.92 3.87 0.35 1.149 2.263
Rank 2	3 1 3	Rank 2

Figure 13: Table for SR

5

Figure 14: Table 5 :

6

Figure 15: Table 6 :

-
- 97 [Abbas et al. ()] 'A review on current research trends in electrical discharge machining (EDM)'. N M Abbas , D
98 G Solomon , M F Bahari . *International Journal of Machine Tools and Manufacture* 2007. 47 p. .
- 99 [Dixit et al. ()] 'An experimental study of material removal rate and electrode wear rate of high carbon high
100 chromium steel (AISI D3) in EDM process using copper tool electrode'. A C Dixit , A Kumar , R K Singh ,
101 R Bajpai . *International Journal of Innovative Research in Advanced Engineering* 2015. 3 (1) p. .
- 102 [Patel et al.] 'Analysis of different tool materials on MRR and surface roughness of Mild steel in EDM'. V D
103 Patel , Mr , C P Patel , Patel Prof , VJ . *International Journal of Engineering Research and Application* 1
104 (3) p. .
- 105 [Choudhary et al. ()] 'Analysis of MRR and SR with different electrode for SS316 on die sinking EDM using
106 Taguchi technique'. S Choudhary , K Kant , P Saini . *Global Journal of Researches in Engineering Mechanical
107 and Mechanics Engineering* 2013. 13. (Issue 3)
- 108 [Haron et al. ()] 'Copper and graphite electrodes performance in electrical discharge machining of XW42 tool
109 steel'. C H Haron , J A Ghani , Y Burhamidin , C Y Swee . *Journal of Material Processing Technology* 2008.
110 201 p. .
- 111 [Jegan et al. ()] 'Determination of electro discharge machining parameters in AISI 202 stainless steel using grey
112 relational analysis'. T M C Jegan , M Dev Anand , M Ravindran , D . *International Conference on Modelling
113 Optimization and Computing*, 2012. 38 p. .
- 114 [Rajendra and Rao ()] 'Experimental evaluation of performance of electrical discharge machining of D3 steel
115 with Al 2 O 3 abrasive mixed dielectric material by using design of experiments'. M Rajendra , K M Rao .
116 *International Journal of Research in Engineering and Technology* 2014. 3 (1) p. .
- 117 [Murikan et al. ()] 'Experimental investigation of dry electrical discharge machining on SS 316L'. R T Murikan
118 , L P Jakkamputi , P Kuppan . *International Journal of Latest Trends in Engineering and Technology* 2013.
119 2. (Issue 3)
- 120 [Haron et al. ()] 'Investigation on influence of machining parameters when machining tool steel using EDM'. C
121 H Haron , B M Deros , A Ginting , M Fauziah . *Journal of Materials Processing Technology* 2001. 116 p. .
- 122 [Rahi and Vishwakarma ()] 'Performance measurement of EDM parameters on high carbon high chromium steel'.
123 D K Rahi , M Vishwakarma . *International Journal of Engineering Research and Development* 2014. 10 (7)
124 p. .
- 125 [Kristian ()] 'Performance of two graphite qualities in EDM of Steel slots in a jet engine turbine vane'. A L
126 Kristian . *Journal of Materials Processing Technology* 2004. 149 p. .
- 127 [Khanra et al. ()] 'Performance of ZrB 2 -Cu composite as an EDM electrode'. A K Khanra , B R Sarjar , B
128 Bhattacharya , L C Pathak , M M Godkhindi . *Journal of Materials Processing Technology* 2007. 183 p. .
- 129 [Lee and Li ()] 'Study of the machining parameters on the machining characteristics in electrical discharge
130 machining of Tungsten Carbide'. S H Lee , X P Li . *Journal of Materials Processing Technology* 2001. 115 p. .
- 131 [Amin et al. ()] 'The implementation of Taguchi method on EDM process of Tungsten carbide'. N Amin , M A
132 Lajis , M Radzi . *European Journal of Scientific Research* 2009. 26 (4) p. .
- 133 [Kojima et al. ()] 'Understanding discharge location movement during EDM'. H Kojima , M Kunieda , N
134 Nishiwaki . *Proceedings International Symposium Electro Machining*, (International Symposium Electro
135 Machining) 1992. 10 p. 144.