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Comparative Analysis of EDM Parameters Influencing MRR, TWR and Surface Roughness for EN-24 and EN-42

Ashutos Shukla¹, Sumit Kumar Singh², Nikhil Bajpai³

¹M. Tech scholar, ^{2,3}Assistant Professor, Department of Mechanical Engineering, Bansal Institute of Engineering & Technology, Lucknow

Abstract: *The present scenario is the advancement of manufacturing industry, and it requires for alloy substances having high level hardness, impact resistance and toughness. The EDM is used in specific cutting complex contours which are complex to machine using traditional machining methods. It is a non-touching non-regular machining method which is used for better quality of product which is complex to achieve by using of contacting EDM processes. The current study on EDM is performed on EN-24 and EN-42 with copper as electrode to establish the influence and compare the process factors on material removal rate, tool wear rate and surface roughness. The experimental outcomes resulted that the material removal rate, tool wear rate and surface roughness are majorly effected by peak current, pulse on time while pulse duty factor was found to be the least influencing parameter for all performance measures.*

Keywords: EDM, EN-24, EN-42, Taguchi, S/N ratio, MRR, TWR.

I. INTRODUCTION AND LITERATURE SURVEY

Electro Discharge Machining (EDM) process is generally an electrical-warm non-conventional material machining technique, which uses electrical energy to produce electrical spark and the material evacuation predominantly happens due to erosion caused by the heat energy of the spark. EDM are generally applied to perform machining operation on hard substance which are not easy to machine and have more strength and are temperature contrary alloys. EDM may also be used for machining complex design in short batches or for on job-shop orient. Experimental substance which should be machined in EDM must be conductor of electricity. EDM is widely used nontraditional machining method for removing material from work-piece without applying any physical cutting force by the tool. Flushing is most vital function in any electrical discharge machining operation. Flushing is the process of introducing clean filtered dielectric fluid in spark gap. Incorrect Flushing can result in inconsistent cutting and poor machining. There are so many literatures in the field of EDM such as: Ojha et al. [1] conducted analysis with Taguchi approach and revealed that current significantly influences MRR, Dimensional Tolerance and surface roughness whereas TWR is mostly influenced by flow rate of the dielectric fluid used. Sari et al. [2] found that carbon Nano-tubes give better surface finish as well as the conventional EDM technique. The thickness of recast layer is observed to be lower when carbon Nano-tubes are used. Kubade et al. [3] investigated that MRR is mainly dominated with current whereas other factors were less influencing. Tool wear rate is most effected by maximum current as well as pulse on time, whereas pulse duty cycle and gap voltage cause low fluctuation on it. Harpuneet et al. [4] Investigated the Effect of Copper Chromium and Aluminum Electrodes on EN-31 Die Steel and concluded that Metal removal rate is better for copper chromium except at 6A current when compared to brass electrode. Maximum MRR was achieved at 12A for both brass and copper chromium. Singh et al. [5] found that the negative polarity of tool is essential for minimizing the roughness of surface and increasing the pulse on time produces more rough surfaces. Addition of powder particles in insulating fluid will decreases the level surface roughness of EDM specimen while larger peak currents offers more rough surfaces. Syed et al. [6] investigated the performance of EDM using aluminum mixed in distilled water and concluded that the polarity causes an important role in EDM. Higher productivity is achieved with positive charge, while better surface finish is obtained in negative charge. The main objectives of the paper are the study the impact of position of unbalanced mass and alter in speed of rotor on shaft vibration.

II. EXPERIMENTAL SETUP AND DATA COLLECTION

Electronica EDM machine used for this experimentation. For the experimentation Copper is used as tool electrode in shape of round bar of 10 mm length and 5 mm in diameter, and EN-24 steel (chemical composition: Fe; 95.7%, Ni; 1.87%, Mn; 0.87%, Cr; 0.72%,

C; 0.41, Si; 0.28%, Mo; 0.21%) and EN-42 (chemical composition: Fe; 95.7%, P; 0.05%, Mn; 0.55%, S; .05%, C; .70% Si; 0.28%) was chosen for as workpiece. Work piece has diameter of 5 mm in round bar. Experiment were conducted to determine MRR, TWR, and Surface roughness for both EN-24 and EN-42 with variation in input parameters. The input parameters and their levels are shown in Table 1., and Table 2. shows the Design of experiment and output Responses. In Table 2. Material removal rate(MRR) is in mm³/min and Tool wear rate (TWR) is in mm³/min and the surface roughness is measured in μm for both EN-24 and EN-42 material.

Table 1. Process Parameters and their levels

S.No.	Parameters	Units	Level 1	Level 2	Level 3
1	Peak Current (Ip)	A	2	5	8
2	Pulse-on-time (Ton)	μsec	20	40	60
3	Pulse duty Factor(T)		5	6	7

Table 2. Design of Experiment and Output Responses

Exp. No	Ip	Ton	T	EN-24			EN-42		
				MRR	TWR	S. R	MRR	TWR	S. R
1	2	20	5	0.459	0.133	6.78	0.401	0.117	5.06
2	2	40	6	0.592	0.172	7.40	0.636	0.186	8.94
3	2	60	7	0.824	0.538	9.72	0.863	0.567	10.28
4	5	20	6	1.832	0.531	6.97	1.835	0.537	8.39
5	5	40	7	2.787	1.617	8.25	2.385	1.395	10.41
6	5	60	5	4.748	4.134	10.12	3.635	3.189	11.86
7	8	20	7	1.474	0.321	6.11	1.467	0.322	8.91
8	8	40	5	3.698	1.073	10.78	2.545	0.744	11.45
9	8	60	6	5.128	3.348	12.43	5.089	3.348	13.69

III. RESULT AND DISCUSSION

Optimal parameters settings are find using Taguchi techniques. In the Taguchi technique, the term ‘signal’ represents the required value (mean) for the output characteristic and therefore the term ‘noise’ represents the undesirable value (standard Deviation) for the output characteristic. The S/N ratio primarily depends upon the standard attributes of the method to be optimized. Generally, there are three categories of performance attributes for the investigation of the S/N ratio; they are the lower is better, the nominal is better, and the higher is better. S/N ratio for each response is typically computed differently as per the classification of the execution attributes and so no matter the class the larger S/N ratio will relate to better process performance characteristic.

A. Calculation of S/N Ratio

To obtain optimal responses, higher-the better-quality characteristic for Material removal rate and lower-the better-quality for Tool wear rate and surface roughness must be taken. The equation for the calculation of S/N ratio is:

For Material removal rate (larger the better): $S/NLB = -10 \log (\Sigma (1/yi^2))$

For Tool wear rate and Surface Roughness is (Smaller the better): $S/NSB = -10 \log ((1/n) \Sigma yi^2)$

Table 3. S/N ratios for MRR, TWR and S. R

Exp. No.	EN-24			EN-42		
	S/N ratio for MRR	S/N ratio for TWR	S/N ratio for S. R	S/N ratio for MRR	S/N ratio for TWR	S/N ratio for S. R
1	-6.7637	17.5230	-16.6246	-7.9371	18.6363	-14.0830
2	-4.5536	15.2894	-17.3846	-3.9309	14.6097	-19.0268
3	-1.6815	5.3844	-19.7533	-1.2798	4.9283	-20.2399
4	5.2585	5.4981	-16.8647	5.2727	5.4005	-18.4752
5	8.9027	-4.1742	-18.3291	7.5498	-2.8915	-20.3490
6	13.5302	-12.3274	-20.1036	11.2101	-10.0731	-21.4817
7	3.3699	9.8699	-15.7208	3.3286	9.8429	-18.9976
8	11.3593	-0.6120	-20.6524	8.1138	2.5685	-21.1761
9	14.1990	-10.4957	-21.8894	14.1326	-10.4957	-22.7281

B. Analysis for MRR

Table 4. shows the means of S/N ratio for material removal rate.

Table 4. Means of S/N ratio for Material removal rate

Materials	Level	Peak current	Pulse on time	Pulse duty factor
EN-24	1	-4.3329	0.6216	6.0419
	2	9.2305	5.2362	4.9680
	3	9.6427	8.6826	3.5304
	Delta	13.9757	8.0610	2.5115
	Rank	1	2	3
EN-42	1	-4.3826	0.2214	3.7956
	2	8.0109	3.9109	5.1582
	3	8.5250	8.0210	3.995
	Delta	12.9076	7.7996	1.9586
	Rank	1	2	3

Fig.1. Main effect plot for MRR of EN-24

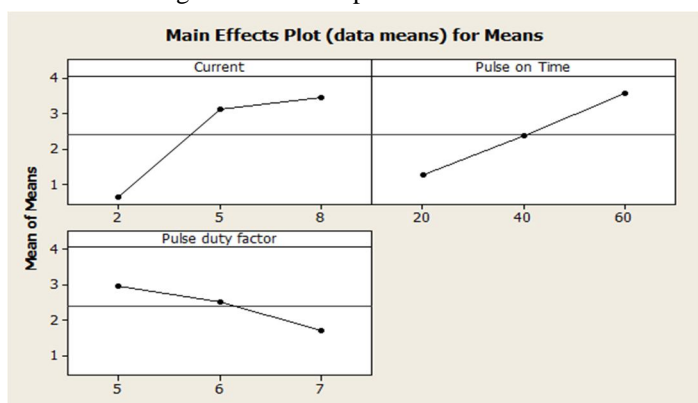


Fig.2. Main effect plot for MRR of EN-42

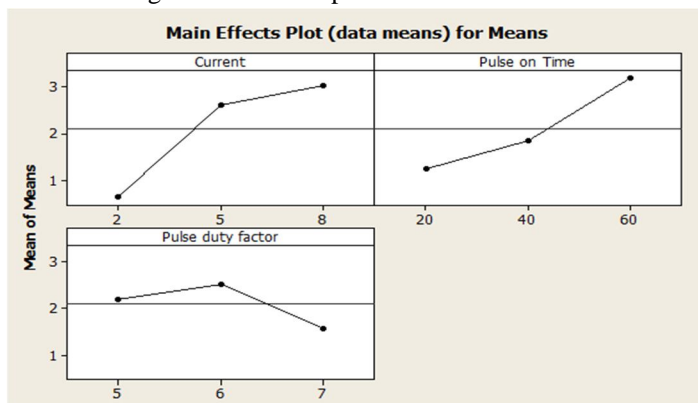


Fig.1. and Fig. 2. presents the mean effect plot for MRR of EN-24 and EN-42 respectively. On observing both the curves for different alternative of EDM, it is noticed as both Ip and Ton are the major influencing alternatives and have direct influence on MRR for both materials. It has seen that MRR proceeds an increasing way with Ip and Ton for both EN-24 and EN-42. This is because at high level of peak charge and Ton, the intensity of spark is high. This results in high transfer of material from the upper layer of the work piece and hence higher MRR is obtained at higher Stage of Ip and Ton. Optimal parameters settings obtained for MRR is as follows: for EN-24

material optimal parameters are Peak current; 8A, Pulse on time; 60µsec and Pulse duty factor is 5, and for EN-42 material optimal parameters are Peak current; 8A, Pulse on time; 60µsec and Pulse duty factor is 6.

C. Analysis For Tool Wear Rate

Table 5. shows the means of S/N ratio for Tool wear rate.

Table 5. Means of S/N ratio for Tool wear rate

Materials	Level	Peak current	Pulse on time	Pulse duty factor
EN-24	1	12.7323	10.9637	1.5279
	2	-3.6678	3.5011	3.4306
	3	-0.4126	-5.8129	3.6934
	Delta	16.4001	16.7766	2.1655
	Rank	2	1	3
EN-42	1	12.7248	11.2932	3.7106
	2	-2.5214	4.7623	3.1715
	3	0.6386	-5.2135	3.9599
	Delta	15.2461	16.5067	0.7884
	Rank	2	1	3

Fig.3. Main effect plot for TWR of EN-24

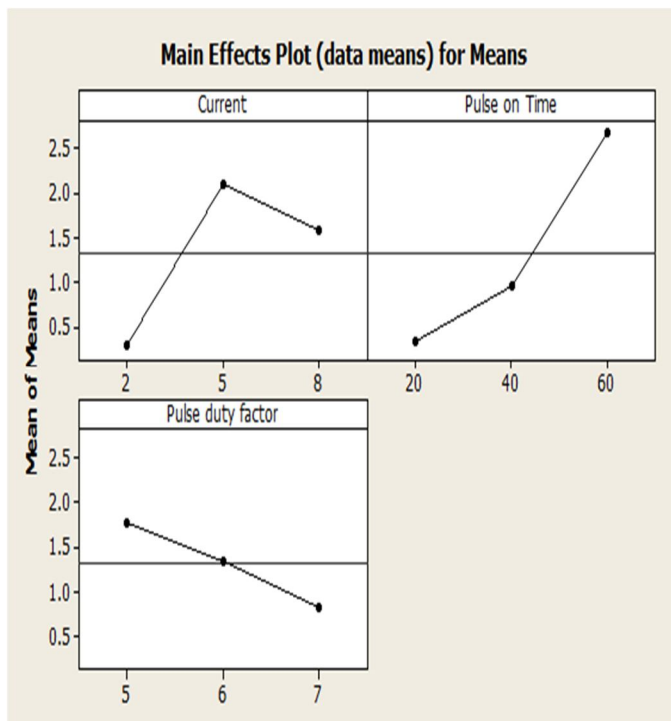


Fig.4. Main effect plot for TWR of EN-42

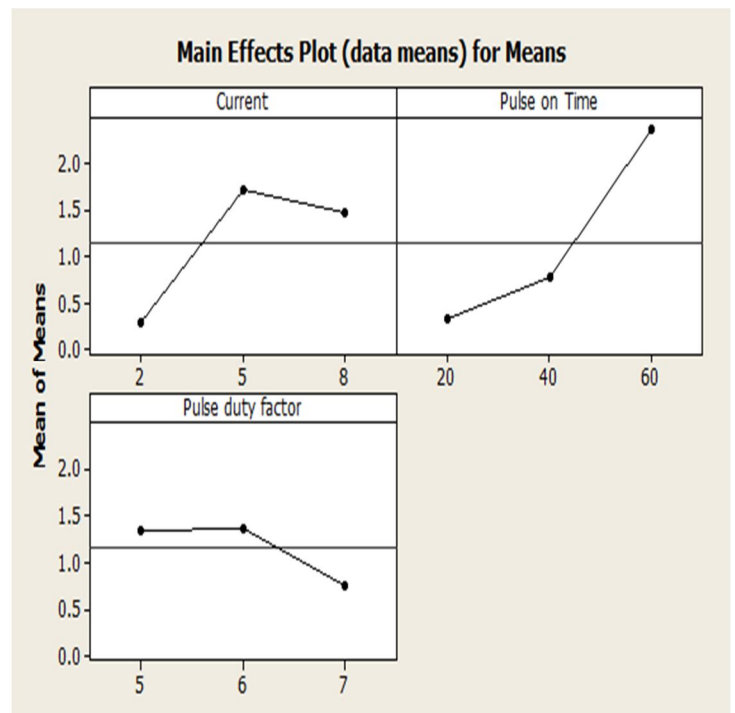


Fig.3. and Fig.4. presents the mean effect plot for TWR of EN-24 and EN-42 respectively. It is noticed that both I_p and T_{on} are the major effective alternative and have direct influence on TWR for both materials. It is seen that TWR follows an increasing trend with T_{on} for both EN-24 and EN-42. In case of peak current, TWR initially increases with it but on further increase in I_p , TWR decreases. This is according to the concept that have higher peak of current, MRR is more and thus the debris present in middle the tool and the experimental substance after material transfer reduces the intensity of electrons striking the surface of the tool. Hence TWR decreases by increment in peak current. Optimal parameters settings obtained for TWR is as follows: Peak current; 2A, Pulse on time; 20µsec and Pulse duty factor is 7, and for both material.

D. Analysis for Surface Roughness

Table 6. shows the means of S/N ratio for Surface Roughness.

Table 6. Means of S/N ratio for Surface Roughness

Materials	Level	Peak current	Pulse on time	Pulse duty factor
EN-24	1	-17.92	-16.40	-19.13
	2	-18.43	-18.79	-18.71
	3	-19.42	-20.58	-17.93
	Delta	1.50	4.18	1.19
	Rank	2	1	3
EN-42	1	-17.78	-17.19	-18.91
	2	-20.10	-20.18	-20.08
	3	-20.97	-21.48	-19.86
	Delta	3.18	4.30	1.16
	Rank	2	1	3

Fig.5. Main effect plot for S. R of EN-24

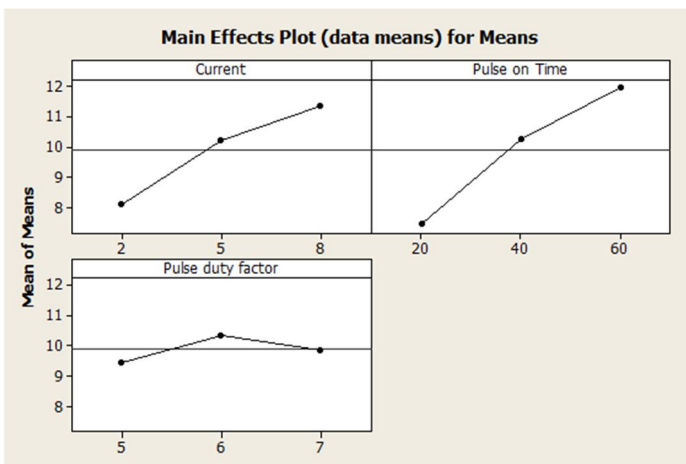


Fig.6. Main effect plot for S. R of EN-42

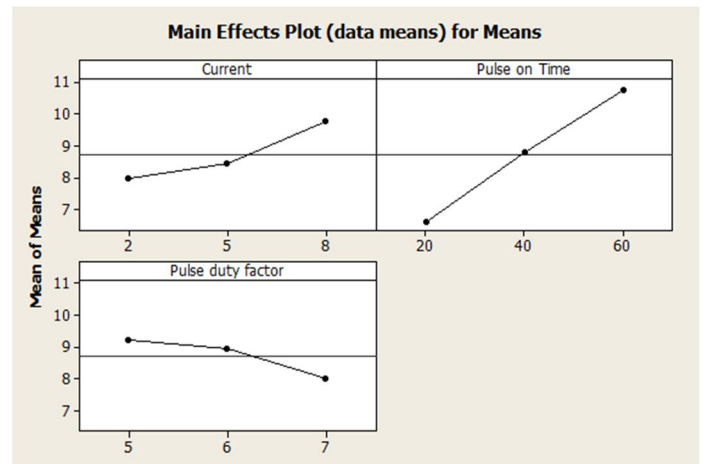


Fig.5. and Fig.6. presents the mean effect plot for SR of EN-24 and EN-42 respectively. This is noticed that both current and Ton are the major influencing alternatives and have direct influence on SR for both materials. It is observed that SR follows an increasing trend with both Ip and Ton for both EN-24 and EN-42. Optimal parameters settings obtained for S. R is as follows: Peak current; 2A, Pulse on time; 20µsec and Pulse duty factor is 7 for EN -24, and for EN-42 material optimal parameters are Peak current; 2A, Pulse on time; 20µsec and Pulse duty factor is 5.

E. Confirmation Test

Confirmation tests have been performed for MRR, TWR and Surface Roughness with their optimum levels of process variables. For EN-24 material, on the taking the optimum parameters value for MRR the results come out 5.06 mm³ /min which is near to the expected value 5.118 mm³ /min, on the taking the optimum parameters for TWR the results come out 0.128 mm³ /min which is near to the expected value 0.141 mm³ /min and on the tanking the optimum parameters for Surface Roughness the results come out 5.06 µm which is near to 5.25 µm.

For EN-42 material, on the taking the optimum parameters value for MRR the results come out 5.089 mm³ /min which is near to the expected value 5.023 mm³ /min, on the taking the optimum parameters for TWR the results come out 0.134 mm³ /min which is near to the expected value 0.139 mm³ /min and on the tanking the optimum parameters for Surface Roughness the results come out 5.08 µm which is near to 5.25 µm.

IV. CONCLUSIONS

It is concluded from the analysis the Peak current and Pulse on time are the major influencing on MRR, TWR and S. R for both materials. MRR shows an increasing trend with Peak current and Pulse on time for both EN-24 and EN-42 because at top level of Peak current and Pulse on time, the intensity of spark is high and hence large amount of material transfer from upper layer of work piece. TWR follows an increasing trend with pulse on time for both EN-24 and EN-42. TWR initially increases with peak current but on further increase in Peak current, TWR decreases. For S. R lower the peak current and pulse on time lower is the surface roughness.

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