© 2018 IJSRST | Volume 4 | Issue 8 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Comparative Study of Electro – Discharge Machining with the use of Additional Rotary Tool EDM Performance During Machining of EN-8 Material

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ABSTRACT

Electrical Discharge Machining (EDM) is a non-conventional machining process in which the machining takes place through spark erosion between tool electrode and workpiece. EDM is used for hard materials which are generally difficult to machine using conventional machining method. Research has been done by comparison of EDM with Rotary EDM with the use of additional rotary attachment on EDM to improve its performance measures like Material removal rate (MRR), tool wear rate (TWR). Various researchers have performed the work on various types of EDMs like Die Sinking EDM, Dry EDM, Powder Mixed EDM (PMEDM) and Wire EDM (WEDM) etc. In this paper objective is to compare EDM with rotary EDM. In this paper there is also a depiction about the machining and non-machining parameters used during the particular research work. In Present paper the research work done on rotary and EDM to improve its performance measures like MRR & TWR.

Keywords: Electrical Discharge Machine, Rotary tool EDM, Material Removal Rate, Tool Wear Rate

I. INTRODUCTION OF ROTARY TOOL EDM

In rotary EDM, rotational movement is imparted to the tool electrode immersed in a dielectric fluid during the machining process. The upper plate of the attachment was attached to ram of EDM machine. DC motor drive provides the rotary motion to the tool electrode. A tool chuck was provided at the bottom of the assembly to hold the tool electrode. In this process cylindrical solid or hollow tube electrode can be used to machine the materials.

The rotary motion is an additional motion imparted to the tool electrode as compared to die-sinking EDM. The various components of the rotary spindle attachment fabricated for the development of Electric Discharge Surface Grinding (EDSG) experimental set up on EDM machine. Setup is used to generate rotary motion for the electrode and is fixed with the quill of the machine. DC motor is attached with the clamp and further with its main spindle. The input voltage is supplied to the rotary arrangement by the DC power supply.

A schematic drawing shown in Fig. 2 and 3 illustrates the fixing of rotary arrangement with the main spindle of the machine. Rotary motion is transferred from horizontal plane to the vertical plane

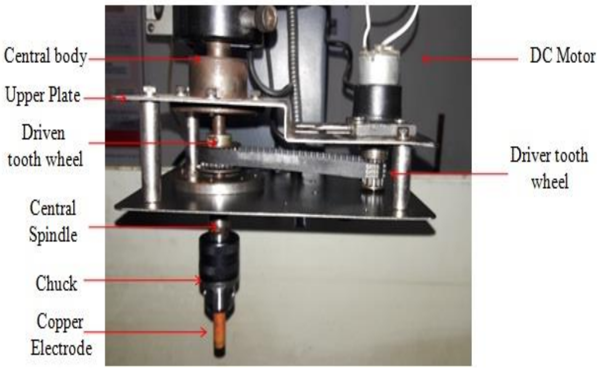


Figure 2 : Rotary Attachment

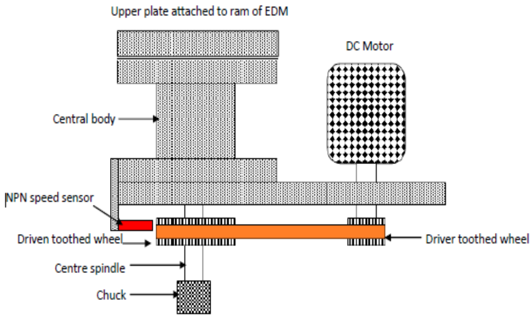


Figure 3 : Components of the electrode rotational attachment

II. SURVEY ON EDM & ROTARY TOOL EDM

Chattopadhyay et.al (2008) examined the machining characteristics of EN-8 steel with copper as a tool electrode during rotary electrical discharge machining process. In the case of MRR and EWR, it has been examined that the decrease in pulse on time, decrease in electrode rotation and increase in peak current, increases both the machining output.

Chattopadhyay et.al (2009) explored the machining qualities of EN-8 steel with copper as a tool electrode during rotary electrical discharge machining process. The experimental models for forecast of output parameters have been created utilizing linear regression analysis by applying logarithmic data transformation of non-linear equation. Three independent input parameters of the model peak current, pulse on time and rotational speed of tool electrode were selected as variables for evaluating the output parameters such as metal removal rate (MRR), electrode wear ratio (EWR) and surface roughness (SR). Analysis has been carried out using Taguchi's suggested signal–noise ratio formula and ANOVA has been conducted to recognize the significant parameters and their degree of contribution in the process output. Analyzed results shows that peak current and pulse on time are the most significant and significant parameters for MRR and EWR, respectively. But peak current and electrode rotation become the most significant and significant parameters for SR, respectively. Experimental results further exposed that maximizing the MRR while minimizing EWR and improving the surface roughness, cannot be achieved simultaneously at a particular combination of control parameters setting. In addition, the predictions based on the above developed models have been verified with another set of experiments and are found to be in good agreement with the experimental results.

Darji & Pillai (2012) have presented that by using solid tool in Micro EDM has been broadly utilized for micromachining of materials like EN-8 steel, composite material, Inconel etc. In this paper it focused on optimization of Material Removal Rate (MRR) utilizing Rotary electrode attachment. The analyses study was led for changing machining parameter like polarity, peak current, rotational speed of electrode and pulse on time utilizing Taguchi system to research the machining qualities of Hastelloy C276 with 0.5 mm Graphite pole as Electrode. Significant machining parameter for MRR were identified by using signal to noise ratio and ANOVA, The results of the Experiment state that Polarity is more in flushing Parameter than Peak current, Rotational speed of Electrode and Pulse on time for material removal rate.

Dave et.al (2013) have explored various effects of basic machining parameters on dimensional accuracy of the micro holes by measuring top and bottom radial overcuts and taper angle and electrode gets more utilized during micro-electro-discharge machining of aluminium (Al 1100) with tungsten electrode of diameter 300μm. The microelectrodes have been cut using a foil electrode and shaped using a Wire Electric Discharge Grinding (WEDG) system. Taguchi methodology has been utilized for design of experimentation with gap voltage, capacitance, and pulse ON time as electrical parameters and thickness and electrode rotation as non-electrical parameters. The result shows that the stationary electrode condition is found to be the optimum condition for top and bottom radial overcuts and taper angle, while for electrode depletion, the lowest level of rotational speed considered for experimentation is observed to be optimal.

Dwivedi & Choudhury (2016a) has performed experiments on AISI-D3 steel using rotary tool motion. The comparison between stationary EDM and rotary EDM is done. The result represents that the tool rotation phenomenon significantly improves the average MRR and surface finish by 41% and 12% respectively. The surface finish was more uniform in structure with less number of micro cracks and thinner recast layer as compared to the stationary tool EDM.

Dwivedi & Choudhury (2016b) focused on the surface integrity improvement of the AISI D3 tool steel using the tool rotation during the EDM process. Surface Roughness (Ra), Micro-Cracks and Recast Layers have been examined and studied as the output parameters. Their research was focused on the surface integrity improvement of the AISI D3 tool steel utilizing the rotary EDM attachment. Surface Roughness (Ra), Micro-Cracks, Recast Layer have been inspected and considered as output parameters. The outcomes demonstrate that the machined work piece has a better surface, fewer micro-cracks and thinner recast layers as compared to the stationary tool EDM process.

Gaur & Bharti (2015) explored the impact of gap current, pulse on time, duty factor, tool electrode rpm and especially the polarity of the machine on Material Removal Rate (MRR) and surface roughness (Ra) for machining of Nimonic alloy. It was examined with suitable control of input parameters of Electrical Discharge Drilling (EDD), MRR and Ra value both found to be improved together from 60 to 90 mg per minute and 4.8 to 2.9 μm respectively which confirm the viability of using tool electrode rotation in EDM machining.

Kumar (2013) has investigated the advancement of Electrical Discharge Machining processes with main focus of the surface quality and MRR. He has concluded that increasing the current, MRR and surface roughness increases and with increase in pulse on time MRR and surface roughness decreases.

Teimouri & Baseri (2012) surveyed on the impact of tool rotation and different intensities of external magnetic field on electrical discharge machining (EDM) performance. The Experiments was done in three parts of low energy, middle energy and high energy. The impact of process parameters were examined on main outputs of material removal rate (MRR) and surface roughness (SR). In order to compare the input parameters and output values two mathematical models were developed to predict the MRR and SR according to variations of discharge energy, magnetic field intensity and tool rotational speed. Results indicated that by applying a rotational magnetic field around the machining gap, improves the MRR and SR. Combination of rotational magnetic field and rotary electrode increases the machining performance, in comparison of previous conditions. This is due to better flushing debris from machining gap. This work introduced a new method for improving the machining performance, in cost and time points of view.

Vincent & Kumar (2016) presented the execution parameters of EDM process to accomplish the feasibility in machining of nitride steel En41b. The machining was done using rotary tubular copper and brass electrodes, in which the tool electrodes may have an additional rotary or orbiting motion, in addition to the servo-controlled feed. Taguchi's signal-to-noise ratio and grey relational analysis were applied in this work to improve the multi-response characteristics such as MRR and EWR on En41b steel and the optimum combination of control parameters such as current, gap voltage, pulse ON time and pulse OFF time were obtained.

III. EXPERIMENTAL SETUP

The Electrical Discharge Machine experiments were carried out using a EA8-S. The Rotary electrode attachment was developed and held on the machine head for performing rotary machining. The work piece material was of EN-8 steel. The Copper rod having 10 mm diameter was used as Rotating Electrode Material. EDM setup and rotary tool attachment used in the present work is shown in Figs. 2 and 3 respectively.

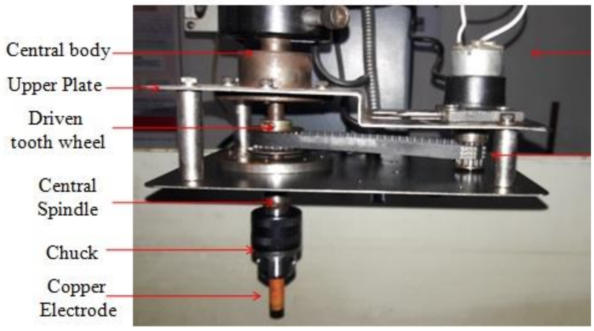


Figure 3. EDM Setup

IV. EXPERIMENTAL PROCEDURE

EN-8 Alloy steel material particulate was using Copper electrode with 10mm diameter. The developed Rotary electrode attachment was held in the machine head for performing Rotary Micro machining is used. Spark Erosion oil was used as dielectric fluid. For a four factor are tackled with a total number of 18 experiments performed on die sinking EDM with rotary attachment . The present experiment was designed based on L9 Orthogonal Array.

The calculation of material removal rate by using electronic balance weight machine. This machine capacity is 200 gram and accuracy is 0.001.

The process parameters chosen for the experimentation are peak current (I), pulse on-time (t_{on}), pulse off-time (t_{off}), electrode speed (N) and other factors such as, gap voltage, machine servo sensitivity and mode of flushing were kept constant during the experimentation. Observation table is shown in Table 2.

The experiment were conducted to see the affect of rotational speed of electrode, peak current, pulse on time, pulse off time on MRR and TWR. The machining condition and number of levels of the parameters selected is shown in Table 1.

Table 1: Design of the experiment with different level

Control Parameters	Units	Levels		
		Level 1	Level 2	Level 3
Peak Current	Ampere	3	7	11
Pulse On Time	μsec	12	15	18
Pulse off Time	μsec	3	6	9
Speed	RPM	100	200	300

The process parameters chosen for the experimentation are Peak Current (I), pulse time-on (t_{on}), Pulse off time (t_{off}) and electrode speed (N) other factors such as gap voltage, machine servo sensitivity and mode of flushing were kept constant during the experimentation.

The experiment were conducted to see the affect of Rotational speed of electrode, Peak current, Pulse on time and Pulse off Time on Material Removal Rate (MRR) using L9 OA. Material removal rate was obtained by calculating the weight difference of work material before machining and after machining per unit time and density of EN8. Weight of work piece was measured with the help of electronic weight balance machine having least count of 0.0001 gm. In this experiment keeping Peak current constant and other parameters like Pulse on time, Pulse off time, Polarity, Rotational speed of electrode variable 18 observation (9 each for rotary EDM and EDM) are done

Table 2: Design matrix and Observation table for Conventional EDM

Sr No	Peak Current	Pulse On time	Pulse Off Time	Speed	Time	Weight of WP		Weight of tool	
						Intial	Final	Intial	Final
1	3	12	3	100	116.75	177.19	176.42	27.72	26.51
2	3	15	6	200	87.51	189.52	188.43	25.84	25.15
3	3	18	9	300	73.43	183.12	182.53	26.81	26.03
4	7	12	6	300	65.11	177.62	176.51	28.21	27.23
5	7	15	9	100	57.27	175.51	174.92	26.22	25.31
6	7	18	3	200	37.49	167.82	167.09	25.91	25.43
7	11	12	9	200	33.21	163.31	162.59	27.12	26.62
8	11	15	3	300	29.12	151.74	151.44	21.95	21.43
9	11	18	6	100	22.41	157.34	156.92	23.73	23.39

Table 3:Design matrix and Observation table for Conventional EDM

Sr No	Peak Current	Pulse On time	Pulse Off Time	Speed	Time	Weight of WP		Weight of tool	
						Initial	Final	Initial	Final
1	3	12	3	100	107.56	188.19	187.42	24.92	24.61
2	3	15	6	200	74.45	187.42	185.72	25.54	25.15
3	3	18	9	300	69.57	183.12	181.05	26.51	25.93
4	7	12	6	300	44.19	179.82	178.41	27.12	26.72
5	7	15	9	100	35.46	178.51	177.82	27.15	26.95
6	7	18	3	200	29.32	177.82	177.04	26.82	26.51
7	11	12	9	200	29.09	165.31	164.74	26.91	26.59
8	11	15	3	300	24.12	164.74	164.13	23.4	23.04
9	11	18	6	100	17.22	163.34	163.07	24.88	24.73

V. Result and Discussion

An investigation to study on MRR and TWR was carried out as discussed above. Result of MRR and TWR found from the experimental investigation is presented in Table 4 & 5. Effect of various parameters on MRR and TWR are discussed below.

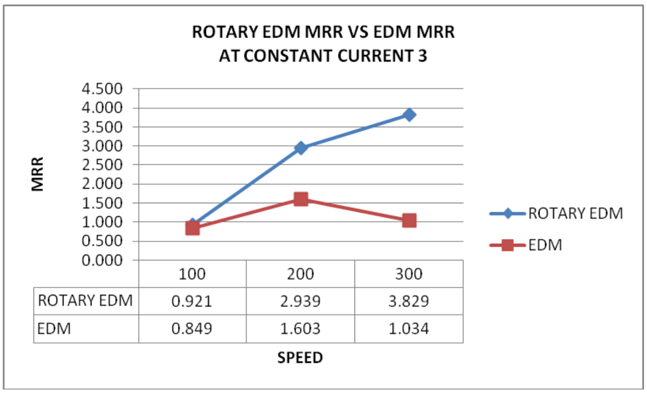
Table 4 Response Table for Rotary EDM

Sr No	Current	Pulse On time	Pulse Off Time	Speed	Time	Weight of WP		MRR	Weight of tool		TWR
						Initial	Final		Initial	Final	
1	3	12	3	100	107.56	188.19	187.42	0.921	24.92	24.61	0.322
2	3	15	6	200	74.45	187.42	185.72	2.939	25.54	25.15	0.585
3	3	18	9	300	69.57	183.12	181.05	3.829	26.51	25.93	0.930
4	7	12	6	300	44.19	179.82	178.41	4.107	27.12	26.72	1.010
5	7	15	9	100	35.46	178.51	177.82	2.504	27.15	26.95	0.629
6	7	18	3	200	29.32	177.82	177.04	3.424	26.82	26.51	1.180
7	11	12	9	200	29.09	165.31	164.74	2.522	26.917	26.59	1.255
8	11	15	3	300	24.12	164.74	164.13	3.255	23.4	23.04	1.666
9	11	18	6	100	17.22	163.34	163.07	2.018	24.88	24.73	0.972

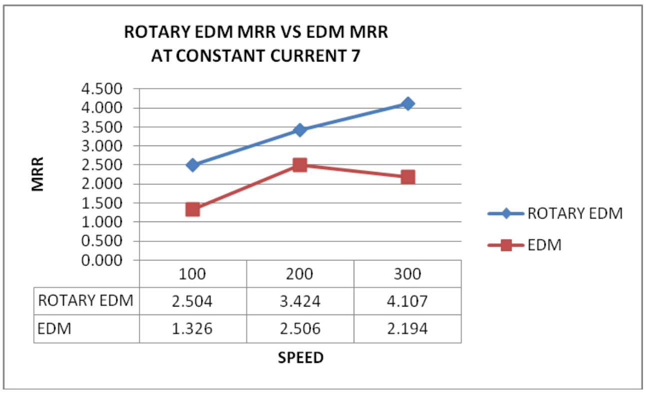
Table 5. Response Table for Conventional EDM

Sr no	Current	Pulse On time	Pulse Off Time	Speed	Time	Weight of WP		MRR	Weight of tool		TWR
						Initial	Final		Initial	Final	
1	3	12	3	100	116.75	177.19	176.42	0.849	27.72	26.51	1.157
2	3	15	6	200	87.51	189.52	188.43	1.603	25.84	25.15	0.880
3	3	18	9	300	73.43	183.12	182.53	1.034	26.81	26.03	1.186
4	7	12	6	300	65.11	177.62	176.51	2.194	28.21	27.23	1.680
5	7	15	9	100	57.27	175.51	174.92	1.326	26.22	25.31	1.773
6	7	18	3	200	37.49	167.82	167.09	2.506	25.91	25.43	1.429
7	11	12	9	200	33.21	163.31	162.59	2.790	27.12	26.62	1.680
8	11	15	3	300	29.12	151.74	151.44	1.326	21.95	21.43	1.993
9	11	18	6	100	22.41	157.34	156.92	2.412	23.73	23.39	1.693

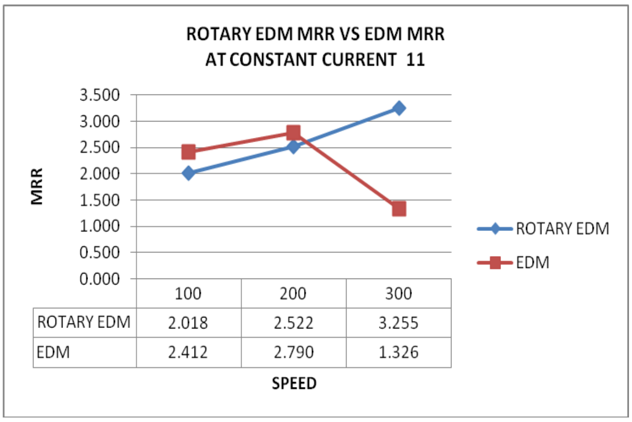
VI. ANALYSIS OF COMPARATIVE RESPONSE PARAMETERS FOR MATERIAL REMOVAL RATE



	100	200	300
ROTARY EDM	0.921	2.939	3.829
EDM	0.849	1.603	1.034

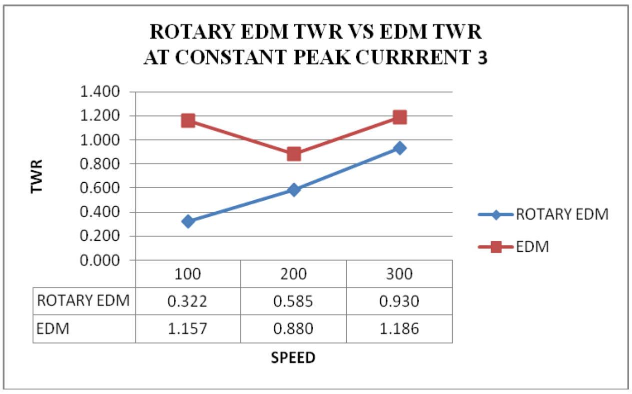


	100	200	300
ROTARY EDM	2.504	3.424	4.107
EDM	1.326	2.506	2.194

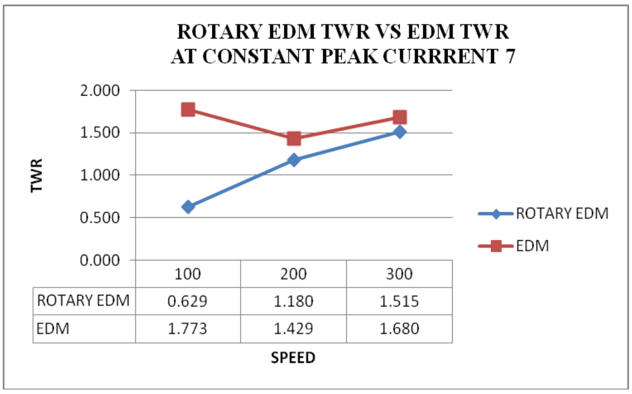


	100	200	300
ROTARY EDM	2.018	2.522	3.255
EDM	2.412	2.790	1.326

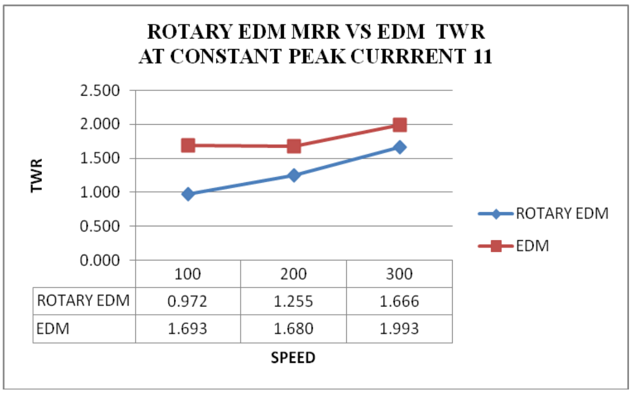
VII. ANALYSIS OF COMPARATIVE RESPONSE PARAMETERS FOR TOOL WEAR RATE



	100	200	300
ROTARY EDM	0.322	0.585	0.930
EDM	1.157	0.880	1.186



	100	200	300
ROTARY EDM	0.629	1.180	1.515
EDM	1.773	1.429	1.680



	100	200	300
ROTARY EDM	0.972	1.255	1.666
EDM	1.693	1.680	1.993

VIII. CONCLUSION

As per the analysis it is observe that the MRR increases as the Speed increases in Rotary EDM as compare to Conventional EDM. It is also observe that the TWR decreases in Rotary EDM as compare to Conventional EDM. Rotary EDM Process holds a bright promising application of EDM, particularly with regard to process productivity and surface quality of work-piece. Rotary EDM can be carried out with the added benefits of flushing out machined debris. Peak current, pulse off time and pulse on time significantly affects the MRR and TWR in EDM.

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