A COMPARATIVE EXPERIMENTAL STUDY ON ELECTRO DISCHARGE MACHINE USING ROTARY TOOL AND DIE SINKING STATIONARY TOOL PERPORMANCE DURING MACHINING OF AL 6061 ALLOY

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Abstract - *Electrical discharge machining (EDM) is a unique machining process in which machining is performed by electric spark corrosion between the tool electrode and the work piece. Research has been done on EDM to improve its performance metrics such as material removal rate (MRR), tool wear rate (TWR), surface roughness (SR) and accuracy size. Many researchers have performed research on different types of EDM such as rotary EDM and die sink EDM,*

In this paper objective is to compare rotary EDM with die sinking EDM. there is also a depiction about the machining and non-machining parameters used during the particular research work. The present research work done on rotary and EDM to improve its performance measures like MRR & TWR.

Key Words: ***Electrical Discharge Machine, Rotary tool EDM, Material Removal Rate, Tool Wear Rate***

1.INTRODUCTION

The research that has been done so far on EDM employing rotary electrodes is primarily focused on high rotational speeds [1,2].

Material is removed by the heat produced during the repeated electric discharge. The workpiece is heated up during the discharge, and the molten material is washed away by the moving dielectric fluid [3]. This thermal material removal procedure produces a heat-affected zone on the surface that can be broken down into a number of layers and sub-layers [4].

The experiment was performed to study the behavior of various process parameters at extremely low electrode rotation speeds. From the results of this experiment, For the low-speed rotation region, MRR decreases with increasing electrode rotation. and Internal overcut and external overcut increase with increasing electrode rotation. Increasing the frequency first leads to an increase and then a decrease in MRR, internal overcutting and external overcutting. The higher the spark gap, the lower the MRR, internal overcut and external overcut.[5].

According to the analysis, it is observed that MRR increases with increasing speed in rotary EDM compared to conventional EDM. The rotary EDM process represents a very promising EDM application, especially in terms of process productivity and surface quality of the workpiece. Rotary EDM can be performed with the added benefit of eliminating machining debris.Peak current, pulse off time, and pulse generation time significantly affect MRR and TWR in EDM.[6]

Die-cast EDM and rotary EDM produced the thinnest white layers with thicknesses of 92 and 30 µm, respectively.Additionally, rotary EDM significantly increases pore formation and ablation.The study also examined the porosity of the machined surface.Sinking EDM produced pores with porosities of 2.339% (best), 5.021% (worst), and 8.101% (optimal), while rotary EDM yielded.This indicates that sinking EDM typically produces lower porosity in machined holes than rotary EDM [7].

In this paper, the effects of rotating electrodes and rotating magnetic fields with different intensities on EWR and OC are studied.The main findings of this study can be summarized as follows. The wear rate of the electrodes increases with increasing discharge energy, but in the high-power regime, the pyrolytic carbon obtained by dielectric liquid deposition in the high-power regime acts as a protective layer.

Protects and reduces EWR.Increasing the electrode rotation speed and magnetic field accelerates electrode wear by removing debris from the machining gap, which limits pyrolytic carbon formation [8].

In this article, an overview of EDM research related to improving MRR is presented. as well as an overview of the basic EDM process and material removal mechanisms. The main research developments leading to improved material removal rates are summarized. Turns out the basis for controlling and improving MRR. [9]

In this study, we investigate the performance of the gas EDM sinking process with the parameters of thermoplastic composite on the MRR machining properties of the electrode, copper-beryllium is the least important coefficient, while the current The maximum is the most important coefficient. The highest MRR value can be achieved with the metal with the combination of the highest heart rate setting and the hourly current level. Changes in peak current and heart rate over time contribute to a large influence on MRR.It can be concluded that a stored spark with higher energy is generated when the peak current increases [10]

Recent advances in several aspects of EDM machining that demonstrate the artistry of the processes discussed above are presented..The researcher strives to improve surface quality, reduce tool wear rate and material removal rate through experimental studies..These research methods such as EDM based on vibration and vibration rotation mechanism, water-based EDM have been used to increase EDM machining efficiency, using dry EDM instead of oil electrolysis, dielectric EDM machining.It also plays an important role in the automotive, optical, jewelry, medical, aerospace industries and the production of various types of mechanical components. [11].

This article discusses the main research areas based on EDM, specifically the influence of different operating parameters of EDM, summarizing the various algorithmic works carried out to optimize the parameters.EDM numbers, overview of advanced work done on EDM, etc.Various studies and improvements in EDM are concluded from many research papers, continued efforts are needed to optimize performance measurement with respect to process variables such as voltage, pulse current and time. pulse amount in EDM machining. Special attention should be paid to monitoring and controlling the EDM process. The EDM process gives better machining efficiency and improved performance.[12]

In this paper, an in-depth study has been presented on the rotary EDM process. The significance of some input parameters was observed on output characteristics such as overcutting and lack of roundness.

It was concluded that rotating the electrode improves roundness, overcutting, and roundness increases as the current increases with both rotating and fixed electrodes.[13]

2. OBJECTIVES AND METHODOLOGY

2.1 Objective of research paper

- Observe the experimental data of rotary electro discharge machining and die sinking stationary electro discharge machining
- Compare the performance of rotary electro discharge machining and die sinking stationary electro discharge machining

2.2 Methodology

Electrical discharge machining (EDM) is a unique machining process in which machining is performed by electric spark corrosion between the tool electrode and the workpiece.EDM is used for hard materials that are often difficult to machine using conventional machining methods. Research has been conducted comparing rotary EDM with the use of sinking EDM to improve its performance indicators such as material removal rate (MRR), tool wear rate (TWR) and surface finish improved..It also affects the overcut and roundness of the machined material.

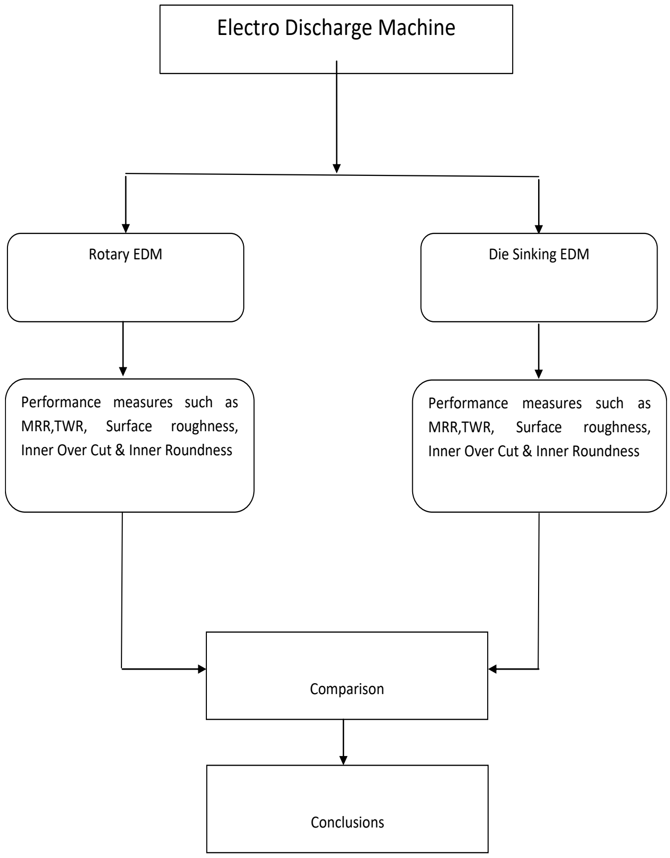

Fig- 1 flow chart of methodology

3. EXPERIMENTAL SET UP

The experiment was performed using an electric discharge machine. Every movement of the machine is controlled by a highly sensitive machine control system. Figure 1 below illustrates the experimental setup of the EDM.A copper electrode shaped like a cylindrical ring at one end is used for machining mild steel billets. The outer and inner diameters of the cylindrical ring finger are 12 mm and 8 mm, respectively. Material removal rate (MRR), internal overcut, and external overcut were selected as response variables.MRR is calculated by measuring the weight of material before and after removal using a digital weight measuring device. The inside cut and outside cut are measured using a digital caliper. To minimize measurement errors, an average of five different readings is taken for the same part.

Fig- 2. Rotary EDM

Fig- 3. Die sinking EDM

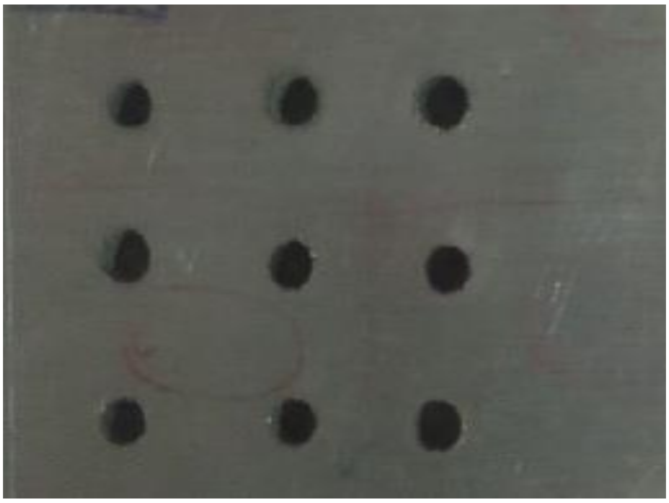

Fig- 4. Specimen of Machined Al 6061 alloy

4. RESULTS AND DISCUSSION

An investigation to study on MRR and TWR was carried out as discussed . Result of MRR and TWR found from the experimental investigation is presented in Table 1 & 2. Experiments were conducted as design of experiment using Taguchi method. Effect of various parameters on MRR and TWR are discussed below.

4..1. Material removal rate and Toll wear rate

Trail	Peak Current in A	Pluse-on Time in µs	Pluse-off Time in µs	Speed in rpm	MRR (mg/min)	TWR (mg/min)
1	6	75	40	100	4.383	0.165
2	6	150	50	150	4.287	0.082
3	6	225	60	200	1.678	0.032
4	10	75	50	200	2.127	0.122
5	10	150	60	100	4.070	0.197
6	10	225	40	150	2.482	0.147
7	14	75	60	150	2.822	0.43
8	14	150	40	200	3.730	0.33
9	14	225	50	100	2.783	0.47

Table -1: Experimental results of rotary EDM

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	MRR in mg/min	TWR in mg/min
1	6	75	40	3.133	0.215
2	6	150	50	3.037	0.132
3	6	225	60	0.423	0.082
4	10	75	50	0.877	0.172
5	10	150	60	2.820	0.197
6	10	225	40	1.232	0.198
7	14	75	60	1.572	0.48
8	14	150	40	2.48	0.38
9	14	225	50	1.533	0.52

Table - 2: Experimental results of die sinking EDM

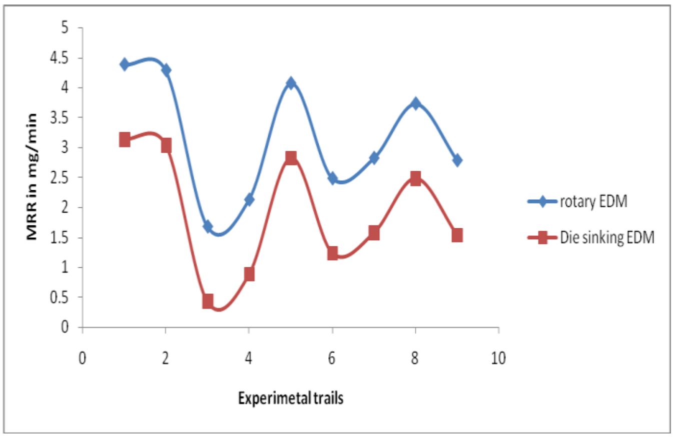

Fig-5. comparison of material removal rate with variation of process parameters

As shown in above figure material removal rate in rotary EDM is higher than the die sinking EDM because of experimental analysis, it is observe that the MRR increases as the Speed increases in Rotary EDM as compare to Conventional EDM.

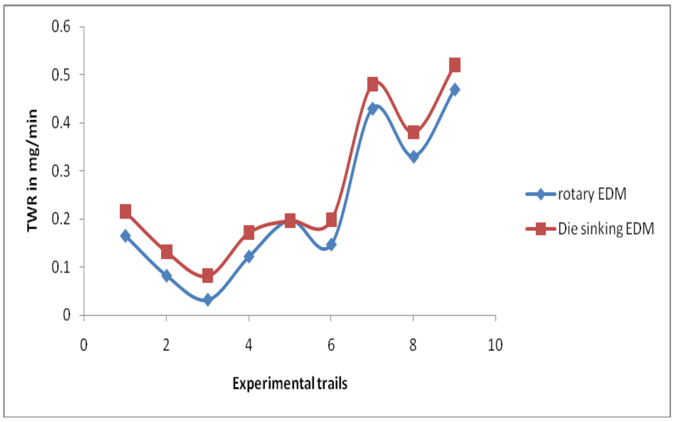

Fig - 6. comparison of tool wear rate with variation of process parameters

As show in above figure material removal rate in rotary EDM is higher than the die sinking EDM because of experimental analysis, 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, Increasing the rotational speed of electrode and magnetic field increases the electrode wear rate due to removing the debris from machining gap which restricts the formation of pyrolytic carbon.

4.2 Surface Roughness

The SR is estimated in this study using a Handy surf instrument. The roughness or smoothness of a particular surface is referred to as surface roughness. It was evaluated using a surface roughness tester and assessed in terms of Ra (Roughness Average), which is an arithmetic average of peaks and valleys of a work piece surface is measured.

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	Speed in rpm	SR in µm
1	6	75	40	100	2.57
2	6	150	50	150	2.915
3	6	225	60	200	3.732
4	10	75	50	200	3.165
5	10	150	60	100	3.385
6	10	225	40	150	3.906
7	14	75	60	150	4.335
8	14	150	40	200	4.062
9	14	225	50	100	3.092

Table -3: Surface roughness results of rotary EDM

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	SR in µs
1	6	75	40	2.820
2	6	150	50	3.165
3	6	225	60	3.982
4	10	75	50	3.415
5	10	150	60	3.635
6	10	225	40	4.156
7	14	75	60	4.585
8	14	150	40	4.312
9	14	225	50	3.342

Table- 4: Surface roughness results of die sinking EDM

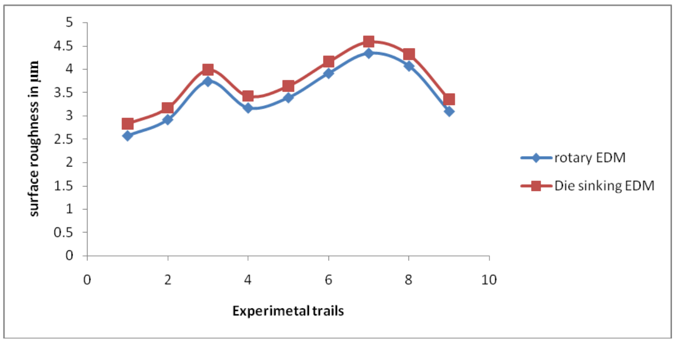

Fig.-7. comparison of surface roughness with variation of process parameters

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. Rotary EDM process produces a thinner and less uniform recast layer compared to Die Sinking EDM. The rotating motion of the tool during EDM drilling sweeps aside resolidified particles, contributing to this difference.

4.3 EDM overcut

It is the depth of the cut made in excess of the tool's diameter. The EDM method frequently results in an impression that is a bit larger than the initial diameter of the tool electrode. This is due to the fact that erosion also happens there because the spark is generated from the side of the tool. Over cut is calculated as half the difference between the diameter of the hole created and the tool diameter.

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	Speed in rpm	Over Cut in mm
1	6	75	40	100	0.270
2	6	150	50	150	0.827
3	6	225	60	200	0.723
4	10	75	50	200	0.312
5	10	150	60	100	0.564
6	10	225	40	150	0.412
7	14	75	60	150	0.620
8	14	150	40	200	0.747
9	14	225	50	100	0.366

Table- 5: Over cut results of rotary EDM

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	Over Cut in mm
1	6	75	40	0.687
2	6	150	50	0.117
3	6	225	60	0.293
4	10	75	50	0.472
5	10	150	60	0.264
6	10	225	40	0.512
7	14	75	60	0.312
8	14	150	40	0.147
9	14	225	50	0.466

Table-6: Over cut results of die sinking EDM

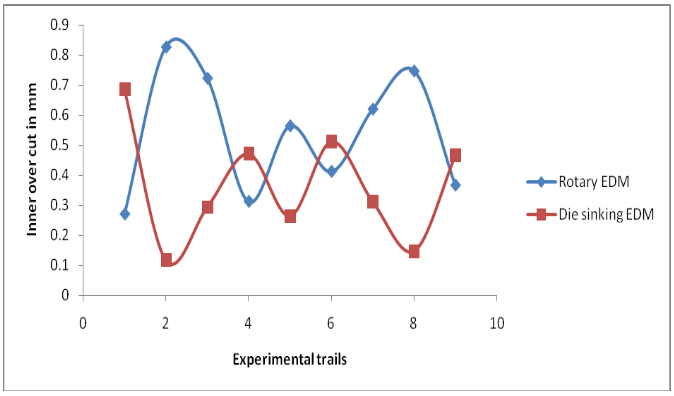

Fig- 8. Comparison of over cut with variation of process parameters

As shown in figure inner over cut is more in rotary EDM compare to die sinking EDM due to vibration of electrode in rotary EDM. Increasing rotational speed of electrode and establishing magnetic field expel the debris from machining gap and trap them between side walls of workpice and tool electrode and increase the overcut. (5) The magnetic field causes changing the ion.

4.4 EDM Out of Roundness

This is due to the fact that as pulse on time grows, less energy is delivered to the work piece as plasma accumulates between the electrode gap and the work piece.

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	Speed in rpm	Out of Roundness in µm
1	6	75	40	100	3.2
2	6	150	50	150	2.1
3	6	225	60	200	3.6
4	10	75	50	200	3.9
5	10	150	60	100	2.8
6	10	225	40	150	3.3
7	14	75	60	150	4.1
8	14	150	40	200	2.3
9	14	225	50	100	2.7

Table -7: Out of roundness results of rotary EDM

Trail	Peak Current in A	Pluse on Time in µs	Pluse off Time in µs	Out of roundness in µm
1	6	75	40	2.2
2	6	150	50	3.3
3	6	225	60	3.7
4	10	75	50	4.9
5	10	150	60	2.8
6	10	225	40	2.5
7	14	75	60	4.1
8	14	150	40	3.2
9	14	225	50	3.1

Table -8: Out of roundness results of die sinking EDM

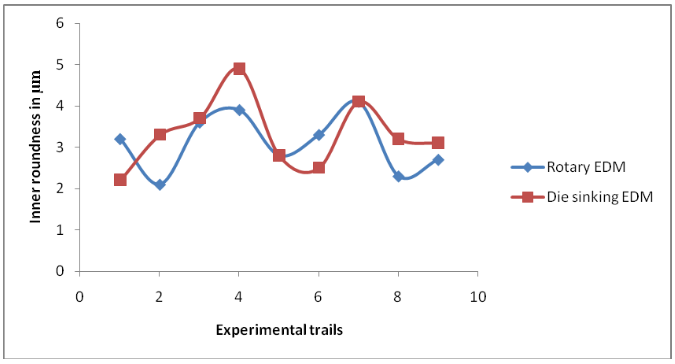

Fig -9. Comparison out of roundness with variation of process parameters

As shown in figure inner roundness is less in rotary EDM compare to die sinking EDM . Rotary EDM improves out-of roundness due to improved flushing. 2. The rotary mode of EDM is better than stationary mode of Machining.

5. Conclusion

The experiment was performed to study the behavior of various process parameters at low electrode rotation speed. From the results of this experiment, following conclusions can be drawn.

(1) For low speed rotation region, MRR increases and TWR decreases with increase in electrode rotation.
(2) Fine Surface roughness is obtained in rotary EDM with increases speed of electrode.

(3) Inner over cut and outer over cut increases with increase in electrode rotation and higher the sparking gap, lower are the MRR, inner over cut, and outer over cut.

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