Experimentally Study the Effect of Polarity and Tool Hole Diameter in EDM Responses.

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Abstract—**This Study is based upon the experiential study which means it is derived from experiment rather than theory. Electric Discharge Machining (EDM) is a thermo-electric non-traditional machining process in which material removal takes place between a pair of electrodes which are submerged in a dielectric medium. In present experiment the effect of polarity on Different EDM (EDM, Dry-EDM and Powder Mixed EDM) has been studied in different polarity and dielectric mediums. It is observed experimentally that increase in tool hole diameter increase Material Removal Rate (MRR) and Tool Wear Rate (TWR). Dry-EDM has negligible TWR. In reverse polarity MRR is very low except Dry-EDM.**

Index Terms—**EDM, Polarity, Dielectric Medium, MRR, TWR**

I. INTRODUCTION

Electrical Discharge Machining (EDM) is one such process developed in the late 1940s [1,2], which is widely used to machine electrically conductive materials. Electric Discharge Machining (EDM) a thermo-electric process in which material removal takes place through the process of controlled spark generation between the tool and workpiece in the presence of a dielectric fluid [3]. EDM does not make direct contact between the tool and workpiece [4,5]. It is also used for finishing parts for aerospace and automotive industry and surgical components that should have electrically conducting [2]. In this process the tool is made of a softer material which can be easily produced by conventional methods, and is then used for the machining of much harder work material. It is generally carried out in a dielectric liquid. So, it can be employed to machine thin and fragile components. The specific advantage of EDM is that the machinability does not depend upon the strength of the material.

Dry Electric Discharge Machining (EDM) is environment-friendly modification of the oil EDM process. Dry EDM uses gaseous medium such as air, argon, helium, oxygen, nitrogen as dielectric instead of mineral oil based liquid dielectric. The dry EDM was first reported in a short NASA technical note [6] in 1985 for drilling using argon or helium gas as a dielectric medium.

On the other hand, it has some limitations like low volumetric material removal rate and poor surface finishing so restricted its further applications [7]. To improve capabilities of EDM process, powder mixed EDM (PMEDM) has developed by mixing suitable powder form (aluminum, chromium, graphite, copper, silicon or silicon carbide etc.) into the dielectric fluid of EDM [7]-[9]. The powder particles in the spark gap get energized and accelerated in a zigzag fashion by the developed electric field and act as conductors. Electrically conductive powder reduces the insulating strength of the dielectric fluid and increases the spark gap between the work piece and the tool.

In EDM process Hydrocarbon oil such as kerosene will decompose and release harmful vapour (CO and CH4) [10]. Water as dielectric is an alternative to hydrocarbon oil. The approach is taken to promote a better health and safe environment while working with EDM. So EDM process on different dielectric medium has to be investigated for better outcomes. Jeswani [11] in 1981 compared the performances of kerosene and distilled water over the pulse energy range 72–288 mJ. He concluded that machining in distilled water has a higher MRR and a lower wear ratio than in kerosene for a high pulse energy range. With distilled water, the surface finish was better but the machining accuracy was poor.

Literature till now is not sufficient to get the optimization values of EDM process. So experimentally investigation the effect of polarity and tool hole diameter on EDM responses has been chosen for the further informations.

II. EXPERIMENTAL SETUP

The experiment set was conducted for 10 minutes on an Electric Discharge Machine, Savita-Economy (India makes) machine using a 10 mm external diameter copper tool electrode. Tool is holed by 6 mm, 5 mm and 4 mm diameter. For all the experiments, the following parameters were set as constant pulse on time (Ton) at 200µs, Discharge Current (Id) at 12 A, Duty Factor at 70%, Gap Voltage (Vg) about 60 V, Gas flow Pressure at 1.5 kg/mm2. Experiment was conducted for different dielectric medium on EN31 steel such as water, kerosene, graphite mixed kerosene and oxygen medium for both reverse and straight polarities. In straight polarity, toolelectrode is connected to cathode (-ve) terminal and workpiece is connected to (+ve) terminal and vice versa for reverse polarity. Further analysis has been done for different tool hole diameter. Copper is taken as tool material. Table 1 shows the properties of EN31and copper materials.

Table I: Properties of the materials

Material	Composition	Hardness	Density
Copper	Copper	40 BHN	8.90 g/cm^3
EN31 Steel	(1%C + 0.2%Si + 0.45%Mn +0.04%S+ 0.04%P+1.3%Cr)	180 BHN	7.81 g/cm^3

Actual amount of material removed and tool wear during EDM is calculated by weight loss method as given in equation (1,2) respectively

$$MRR = \frac{[\text{workpiece weight loss in gms}] \text{ X } 1000}{\left[\text{Density in} \frac{gm}{cc}\right] x [\text{Machining time in mins}]} \text{ ----1}$$

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$$TWR = \frac{[\text{Tool weight loss in gms}]\ X\ 1000}{\left[\text{Density in} \frac{gm}{cc}\right] x [\text{Machining time in mins}]} \text{ ----2}$$

III.OBSERVATIONS

The response observation table for MRR and TWR for the straight and reverse polarity is shown in Table II.

Table II: Observations Table

Type of EDM	Dielectric	Hole diameter (mm)	Workpiece MRR (mm^3/min)		Tool TWR (mm^3/min)	
			Straight	Reverse	Straight	Reverse
Oil EDM	Water	4	34.826	1.154	3.933	0.337
		5	36.724	0.897	5.506	1.236
		6	37.451	0.641	7.528	0.899
Oil EDM	Kerosene	4	32.979	0.513	1.461	0.337
		5	34.657	0.641	2.36	0.112
		6	34.097	0.769	2.921	2.809
PMEDM	Graphite mixed Kerosene	4	35.014	0.763	1.462	1.278
		5	38.146	0.986	2.146	2.002
		6	40.124	1.244	2.468	2.984
Dry-EDM	Oxygen	4	17.049	9.872	0.112	0.337
		5	24.875	12.436	0.225	0.225
		6	34.657	16.923	0.225	0.112

IV. Results and Analysis

Experimental results are analyzed for MRR and TWR to the tool hole diameter and polarities.

A. Analysis of MRR:

The variation of MRR to tool hole diameter is shown in Fig. I & II for straight and reverse polarity respectively. And also the variation of MRR to polarity for different tool hole diameter 4 mm, 5 mm and 6 mm is shown in Fig. III, IV and V respectively.Experimental results show that the MRR tends to increase with increase of tool hole diameter. Maximum MRR can be found by PMEDM. Dry-EDM has meaningful machining in both polarities but no meaningful machining for oil EDM and Powder Mixed EDM (PMEDM) in reverse polarity as shown in Fig. I, II, III, IV& V.

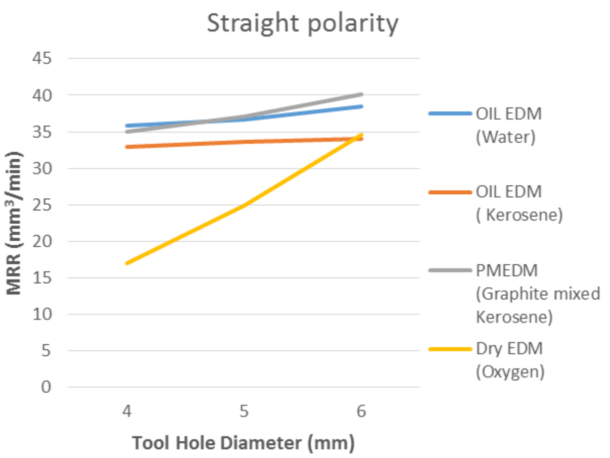

Fig. I MRR vs Tool hole Diameter (Straight polarity)

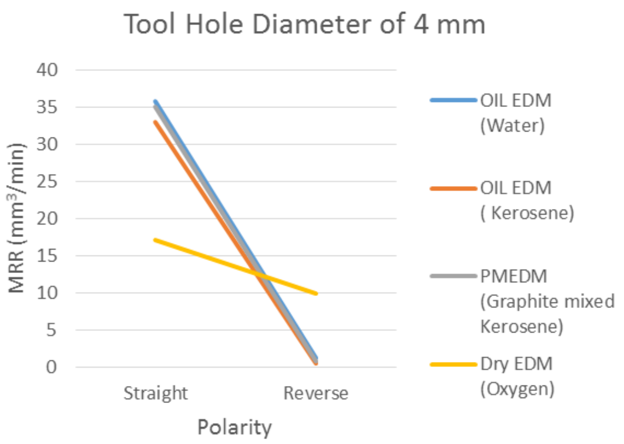

Fig. III MRR vs Polarity (for tool hole diameter 4 mm)

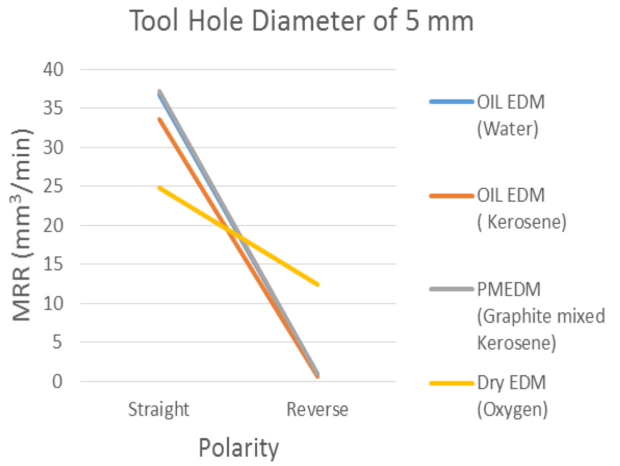

Fig. IV MRR vs Polarity (for tool hole diameter 5 mm)

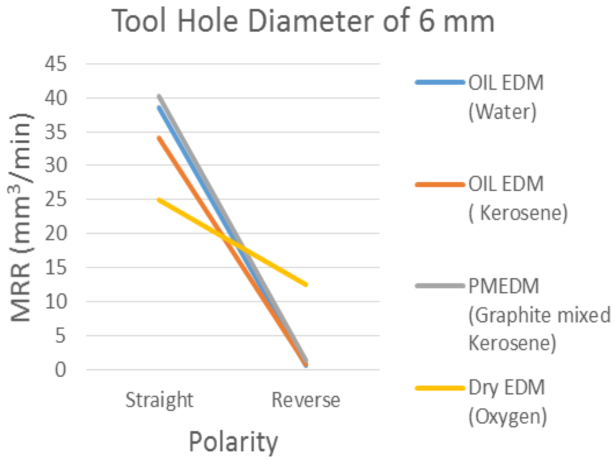

Fig. V MRR vs Polarity (for tool hole diameter 6 mm)

B. Analysis for TWR:

The variation of TWR to tool hole diameter is shown in Fig. VI &VII for straight and reverse polarity respectively. And also the variation of TWR to polarity for different tool hole diameter 4 mm, 5 mm and 6 mm is shown in Fig. VIII, IX and X respectively. Experimental results show that the TWR tends to increase with increase of tool hole diameterexcept in the case of Dry-EDM. Maximum TWR is occurred at Oil EDM. Dry-EDM has negligible TWR in both polarities but other oil EDM and Powder Mixed EDM (PMEDM) has considerable TWR in straight polarity as compared from reverse polarity as shown in Fig. VI, VII, VIII, IX&X.

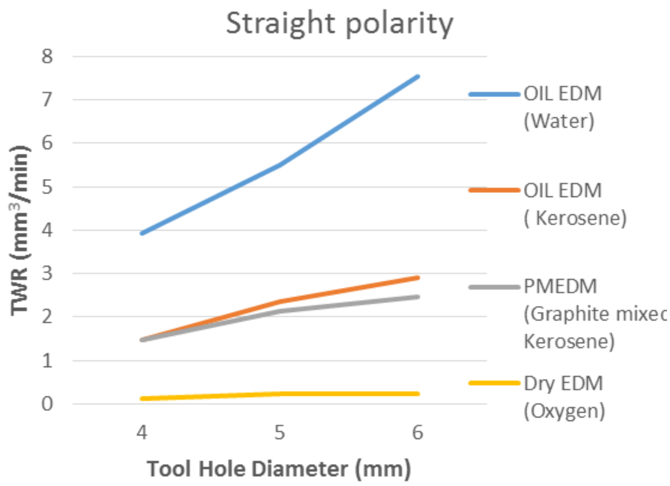

Fig. VI TWR vs Tool Hole Diameter (Straight polarity)

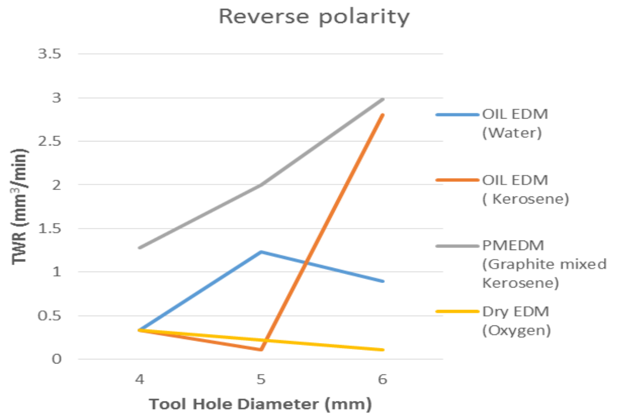

Fig. VII TWR vs Tool hole Diameter (Reverse polarity)

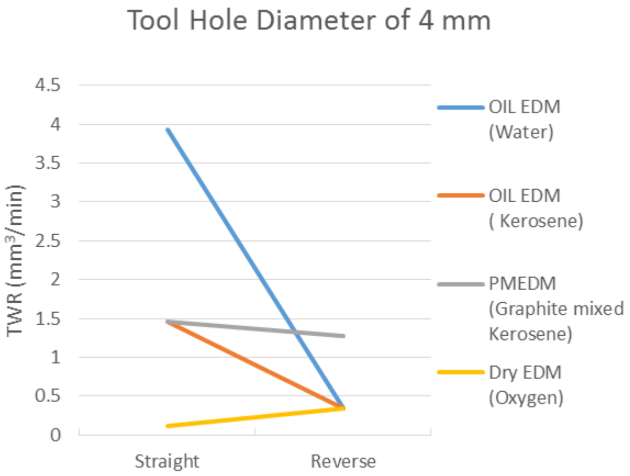

Fig. VIII TWR vs Polarity (for tool hole diameter 4 mm)

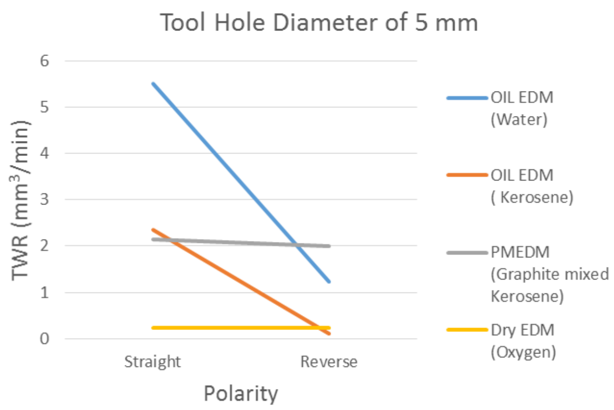

Fig. IX TWR vs Polarity (for tool hole diameter 5 mm)

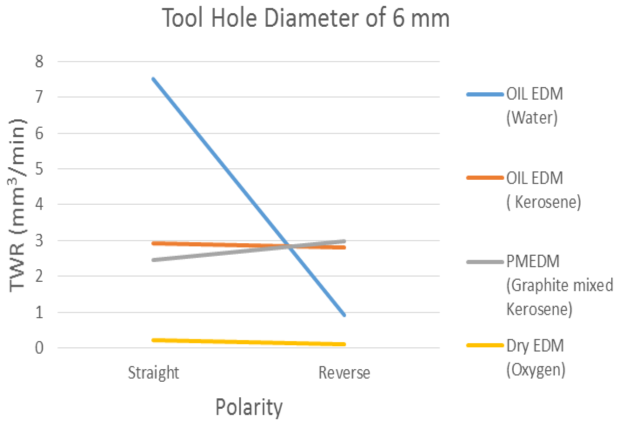

Fig. X TWR vs Polarity (for tool hole diameter 6 mm)

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V. Conclusion

The following conclusions are found from the experiment that increase in tool hole diameter increase both MRR &TWR. The dry EDM gives negligible tool wear rate. Tool Hole Diameter has more effective on dry EDM in both the polarity. Experiment is more suggested to study different powder mixed to dielectric medium for better MRR and TWR.

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