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Effect of Different Electrodes and Dielectric Fluids on Metal Removal Rate and Surface Integrity of Electric Discharge Machining: A Review

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ABSTRACT

EDM is one of the oldest un-conventional machining process which is based on thermoelectric energy between the work piece and an electrode. It is used for manufacturing of intricate shape or extremely hard and electrically conductive material parts, which are not easily machined by other conventional machining processes. It is generally used in dies and mould making industries and in machining automotive, research, aerospace, and surgical components. In this paper various aspect of Electric Discharge Machining for Metal Removal Rate, surface integrity for different material, electrodes and dielectric fluids have been elaborated by reviewing the contribution of various researchers. The performance of the EDM process is largely is dependent on the work piece material, design of the electrodes and very much on which type of dielectric fluid are used. Currently the use of Kerosene with copper electrode in EDM is on peak but the use of other dielectric fluid such as EDM oil, water, water with additives like Servotherm, powder additives dielectric like graphite powder, Al powder, titanium powder etc. gives better performance. In this present review work has been done on researches done so far in EDM in terms of variety of alternative fluids and electrode on their influences on EDM performance.

Key words: EDM, Metal Removal Rate, Surface Integrity, dielectric fluid, Electrode.

1. INTRODUCTION

Electrical discharge machining (EDM) is a most populated un-conventional machining processes in which material is removed by electro thermal energy by a series of successive discrete discharges or sparks between a pair of electrically conductive materials i.e. work piece and electrode tool which are submerged in the dielectric fluid [1]. EDM process is widely acceptable in industries.

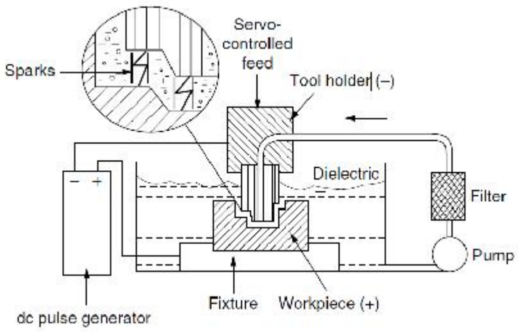

Fig.1 Schematic diagram of EDM [1]

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Due to its capability to machine conductive very hard materials and produces geometrically complex shapes that are relatively more difficult to produce using traditional machining processes. Very Thin and brittle objects can be machined without the risk of breakage [2]. It is generally used in dies and mould making industries and in machining automotive, research, aerospace, and surgical components. The performance of the EDM process is largely is dependent on the work piece material, design of the electrodes and also very much on which type of dielectric fluid are used.

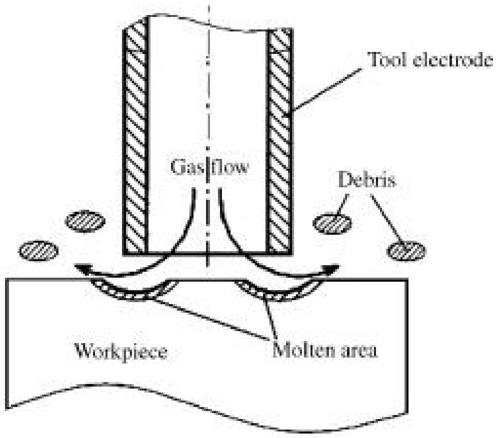


Fig.2 Principle of EDM [6]

The electrode tool is moving toward the work piece by servo mechanism until the gap is narrow that gap apply voltage for ionization of dielectric fluid. The EDM generator generates spark between the electrode and work piece for very instant time in the gap. [4] Due to sparking high heating of electron generates high temperature and erosion of material takes place with the erosive effect and the eroded particles are flashed away with the help of dielectric fluid. This process repeats every millisecond. While machining tool and work piece maintain some narrow gap so that it eliminates mechanical stresses, chatter and vibration problems.

2. DIELECTRIC FLUID FUNCTION

Kern R. (2009) was concluding that the dielectric fluid serves number of function in Electro discharge machining as: [7]

- It acts as a medium so that smooth and controlled machining happen.
- It acts as a cooling medium.
- Is use for flushing debris and eliminate the stacked debris.
- it also transfers the heat

3. EFFECTS OF DIELECTRIC FLUIDS AND ELECTRODES ON MRR AND SR.

Various researchers have studied on different dielectric fluid with different electrode on material and calculate the MRR and SR on various aspects.

3.1 KEROSENE WITH COPPER ELECTRODE

Ahmad and Lajis (2013) was conducted the experiment on nickel alloy in kerosene with copper electrode and conclude that peak current affects the MRR greatly. A raise in peak current MRR increases up to 34.95 mm^3/min and surface roughness about the 8.53µm at 20A current. [8]

Sin and Kim (2003) conducted the experiment on hastelloy with copper electrode in kerosene and showed that when pulse on time is lesser (50 µs) then the MRR is highest with 5A current and MRR is lower in case when the pulse on time is increasing (600µs) at the same current [9]

R. Jothimurugan and Amirthagadeswaran (2014) has conducted the experiment on Monel alloy 400 with copper electrode in kerosene they conclude at 75:25 proportion of kerosene and servotherm gives the MRR about 1.80 times greater than kerosene and high roughness is imparted to the machined surface. [10]

Teepu Sultan et al (2014) was conducted the experiment on EN353 die steel using copper electrode in kerosene and they mention the MRR of die steel EN 353 is between 14 mm^3/min and 29.03 mm^3/min. And the optimize value of MRR 17.62 mm^3/min and SR is 4.54 µm. [11]

S. Gopalakannan et al (2013) has conducted the experiment on Al/SiC metal matrix nanocomposites with copper electrode in kerosene and they found the actual value of MRR is 1.196 gm/litre and SR is 10.648 µm. [12]

Guu and Hau (2007) has conducted the experiment on Fe-Mn-Al alloy with copper electrode in kerosene dielectric fluids and show the SR is increasing at increasing in pulse current and the range was from 81nm to 296nm. [13]

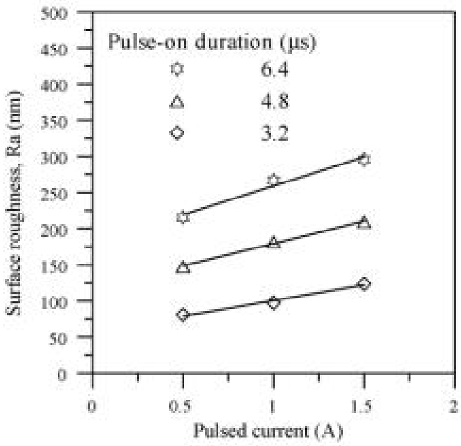
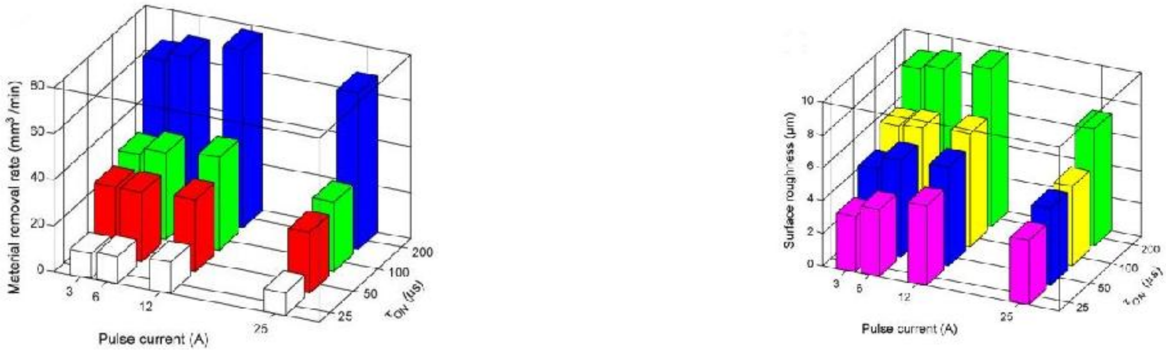


Fig.3. The average surface roughness at various machining conditions. [13]

Khan (2008) has conducted the experiment on mild steel and aluminium with copper and brass electrode and conclude that The MRR increases sharply with increase in current and better SR was obtained while machining of Al using a copper electrode and more MRR by using brass electrode on Al. [14]

3.2 KEROSENE WITH GRAPHITE ELECTRODE

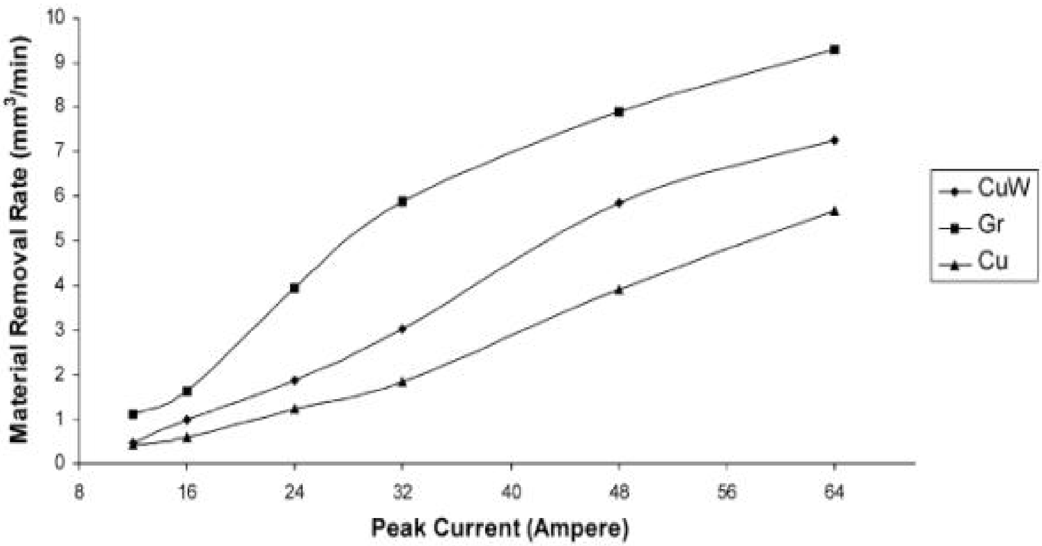
Ahmet Hascalık et.al. (2007) has investigating on titanium alloy (Ti–6Al–4V) in kerosene dielectric with the different electrodes like Al, Cu, Brass. They found that Graphite electrode gives the higher MRR among all of them and that was 77.185mm^3/min. [15], and it gives the surface roughness of 9.74 µm.



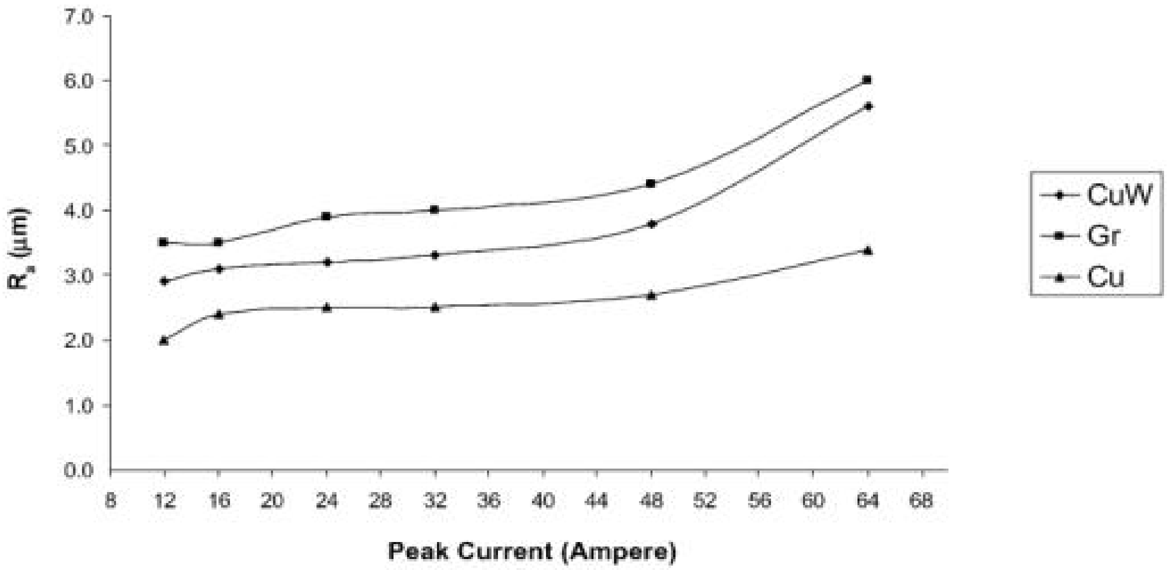
(a) (b)

Fig.4 Effect of (a) MRR and (b) SR with graphite electrode in kerosene [15]

S.H.Lee (2001) has conducted the experiment on tungsten carbide with three different electrodes graphite, copper and copper tungsten in kerosene and they shows that graphite gives the greater MRR among all of them.[16]



(a)

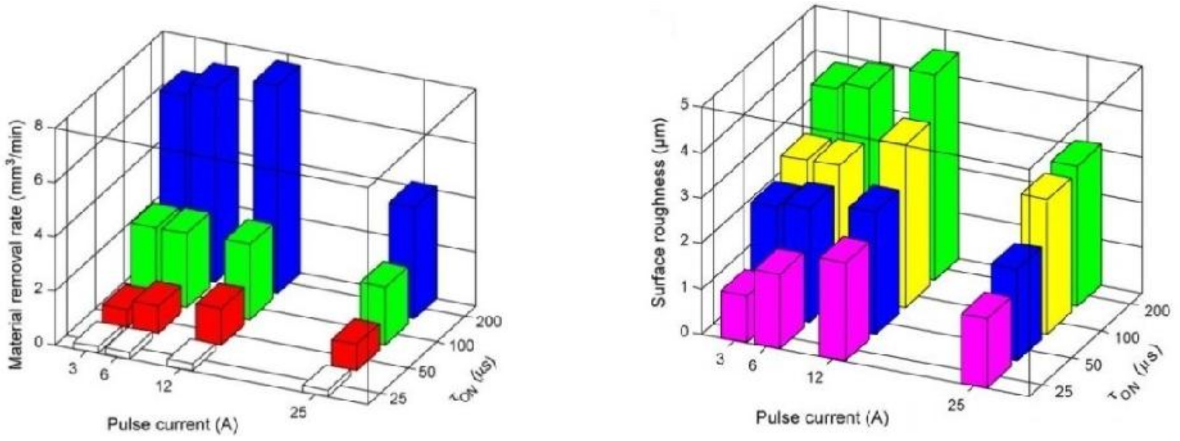


(b)

Fig.6 Effect of electrode material on (a) MRR and (b) SR [16]

3.3 KEROSENE WITH ALUMINIUM AND COPPER TUNGSTEN ELECTRODE

Ahmet Hascalık et.al. (2007) has investigating in kerosene dielectric with the different electrodes like Al, The MRR is 7.8mm^3/min. and surface roughness increasing with process parameters that is 4.56 µm at 12A current and 200µs pulse on duration. [15]



(a) (b)

Fig.7. Effect of Al electrode on (a) MRR and (b) SR[15]

Soni and Chakraverti (1996) was conducted the experiment on high carbon high chromium (HCHCr) die steel with CuW electrode in Kerosene dielectric and they conclude that some amount of element was migrated to workpiece from tool and occurs reverse phenomenon also. [17]

Rival (2005) has performed the experiment on titanium alloy using CuW electrode with SiC powder in Castrol 180. He investigates when Adding SiC powder up to 2 gm/ltr in EDM oil it improved the surface quality. However, higher concentration of SiC powder (above 6 gm/ltr) tends to worsen surface quality. [18]

3.4 COPPER ELECTRODE EDM OIL AND MINERAL OIL

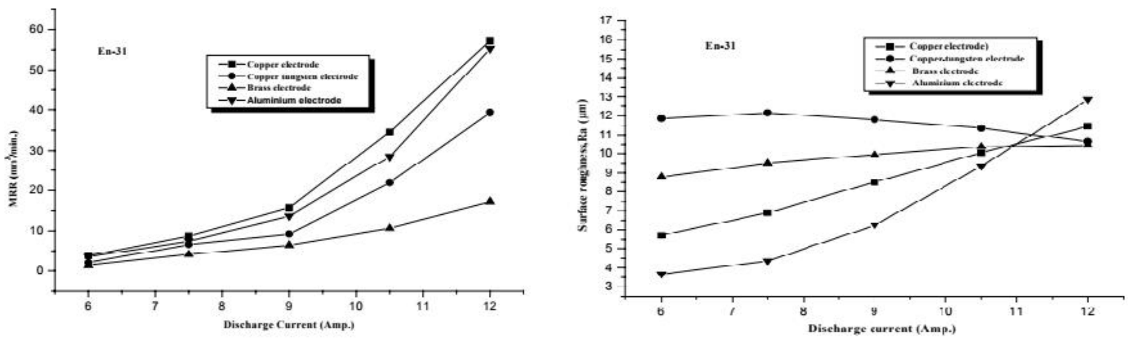
Anil Kumar et al (2011) were conducted the experiment on Inconel 718 alloy with copper electrode in EDM oil with aluminium powder as additives in 6gm/litre. This leads the SR is improved by 18% and MRR is increased about 46 %, and Maximum MRR is obtained at 5 A of peak current. [19]

Torres et al (2015) conducted his experiment on nickel alloy 600 with copper electrode in mineral oil at positive and negative both polarity and conclude that positive polarity and high current intensity values gives higher MRR. The highest value of the material removal rate is 22.57mm^3/min at 8A current intensity and 50µs pulse time. The average surface roughness is 1.11µm and also concludes that negative polarity gives better SR. [20]

I.Puertas et al (2004) found in his experiment on cobalt bonded tungsten carbide (WC-Co) with copper electrode in EDM oil was the varying intensity and pulse time. The MRR tends to increase and MRR increases when intensity increases. [21]

3.5 EDM OIL WITH CU, CUW, AL AND BRASS ELECTRODE

Shankar Singh et al (2004) has conducted the experiment on tool steel with copper, copper tungsten, brass and aluminium electrodes in EDM oil and they found that The copper and aluminium electrodes gives the best metal removal rate and Brass gives good surface quality by comparing the four electrodes. [22]



(a) (b)

Fig.8 effect of Al, Cu, Brass and CuW electrode on (a)MRR (b) SR on tool steel [22]

3.6 DEIONISED WATER WITH DIFFERENT ELECTRODE

M. Manjaiah, et al (2014) was conducted the experiment on shape memory alloy of titanium and nickel with brass electrode in deionised water, they reported that surface shows the coral reef microstructure so that the surface roughness is 2.47 µm and MRR is 8.341 mm3 /min. [23]

Hamid Reza (2012) had performed the experiment on smart NiTi alloy with graphite electrode and deionised water and they reported that the maximum rate of material removal is obtained at 15A discharge current, 80V voltage, and pulse-ON-time of 35µm. Maximum surface roughness is achieved at discharge current of 10A, voltage of 80V, pulse-ON-duration of 35µs and pulse-OFF-duration of 70µs. [24]

Tariq et.al. (1984) had performed experiment on the different type of water in EDM as they use distilled water, with copper and brass electrode, they show that tap water and a mixture of 25% tap water and 75% distilled water and found that the tap water gives the best machining rate. [25]

Konig et.al. (1987) experimented and found that the effect of working fluid on MRR. In their study it is concluded that the dielectric fluid has sustained effect on removal process and in water based medium much higher power input and thermal stability is obtained at critical condition results in better removal rate [26].

Yan et.al. (2005) conducted experiment and obtain that TiN on the work surface Both MRR and TWR decrease with an increase in pulse duration. Hardness values are near about of 250 HK (Knoop hardness) were achieved and also good surface finish. [27]

3.7 ADDITIVE MIX DIELECTRIC FLUIDS WITH DIFFERENT ELECTRODES

Kansal et.al. (2007) has conducted the experiment on AISI D2 die steel with silicon powder 4gm/litre mixed kerosene oil and conclude that Peak current and amount of silicon powder are the most affected parameters for material removal. More concentration of silicon powder in the dielectric fluid increase material removal rate. [28]

Shankar Singh et al (2004) has conducted the experiment on En-31 tool steel with copper, copper tungsten, brass and aluminium electrodes with addition of graphite powder in EDM oil 6 gm/litre and shows an improvement in material removal rate by 3.29 times and 1.74 times than kerosene & EDM oil respectively. In addition, it also imparts better surface finish than kerosene and EDM oil. [22]

4. CONCLUSION

Lots of papers have been published on Electro Discharge Machining on its various aspects. EDM has widely used in industries and general shop floor to do machining of “difficult to machine” material and for intricate shapes. In this present review paper study has been done on researches done so far in EDM in terms of variety of alternative fluids and electrode on their influences on EDM performance. Currently the use of Kerosene with copper electrode in EDM is on peak but the use of other dielectric fluid such as EDM oil, water, water with additives like servotherms, powder additives dielectric like graphite powder, Al powder, titanium powder etc. gives better performance. Brass electrode gives good surface finish but not better MRR in EDM. After reviewing lots of papers we conclude that graphite gives the best MRR with additive mix Kerosene and best surface quality is obtain with copper electrode.

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