Review on Process Parameter of EDM & micro EDM

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Abstract: Electric discharge machining is a non-conventional machining method and it is widely used in aerospace,automobile and pharmaceutical industries. In Present research work a detailed review is given on different process parameter utilized in micro-EDM and their utility in different research application.

INTRODUCTION

Production of difficult material and hard material by traditional method is difficult by traditional method especially where miniaturization is required hence there is requirement of non-conventional method for the machining these type of material.

One such method is EDM & micro EDM. Electro Discharge Machining (EDM) is an electro-thermal non-traditional no physical cutting forces between the tool and the workpiece where material is removed using thermal energy by generating a spark between two opposite polarity to erode the work-piece. (Bhardwaj et al(2013a).

The material is removed by a a series of rapidly recurring spark discharges between the two electrodes under the presences of dielectric fluid which results in high temperature of order of 8,000 ^{0}C to 12,000 ^{0}C. With the advancement in material science which have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties, Edm has proved to be very effective process to machine metals irrespective of their hardness and different mechanical properties. Change in thermal properties has very little effect on the process. (Leera Raju et al(2016) μ-EDM capability to machine microstructures of varying complexity levels on difficult to cut metals and alloys. the term micro-machining defines the processes that machine dimensions in the range of 1 μm to 999 μm (Kanlayasiri et al 2007). μ- EDM has gained importance because of its ability to produce stress free micro sized cavities of desires shapes on conducting and semi conducting materials.

Even the principle of EDM and μ- EDM are same but there are differences due to scaling effect Table 1 shows the major differences between the conventional EDM and μ-EDM.(Leera Raju et al 2016).

Major differences between conventional EDM and μ-EDM

Parameters	Conventional EDM	μ-EDM
Size of tool	Greater than 999 μm	Lesser than 999 μm
Inter-electrode gap	10 to 500 μm	Less than 3 μm
Open Circuit voltage	4-400 V	10-120 V
Peak Current	Greater than 3A	Less than 3A
Pulse-on time	0.5 to 8μs	50 μs to 100 μs
Specific Energy	High	Low

Basic principle

The basic principal followed is the conversion of electrical energy into thermal energy through a series of recurring spark discharges between the two electrodes (Tsai et al)
During this process two electrode are kept at a certain distance and ignition voltage of 200V is given and breakdown of dielectric medium occurs which results in electric spark and increases the temperature ,the increased temperature creates thermal erosion and hence material is removed.

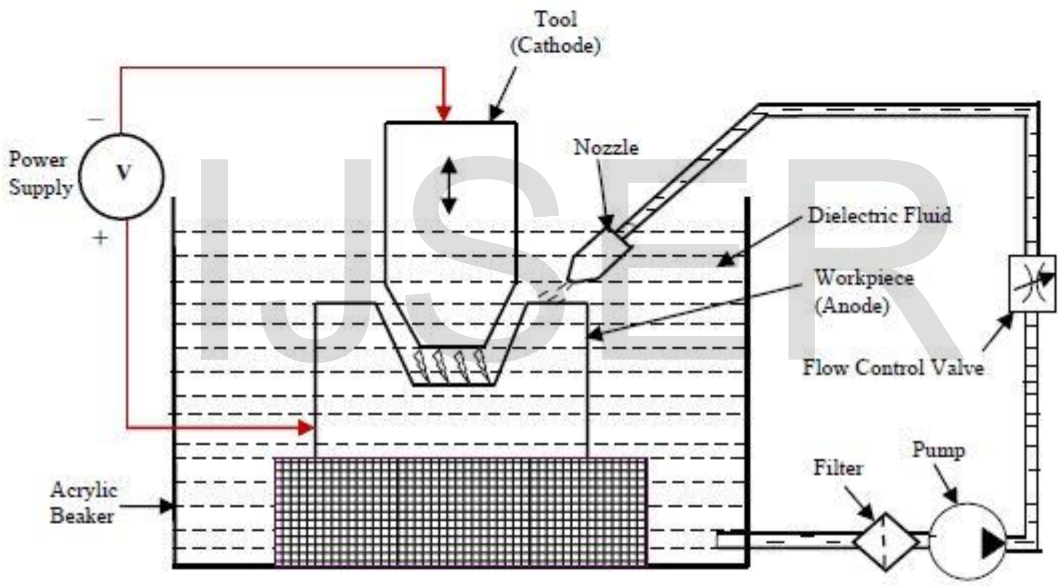


Fig. 1. Schematic representation of EDM cell.

Components of EDM

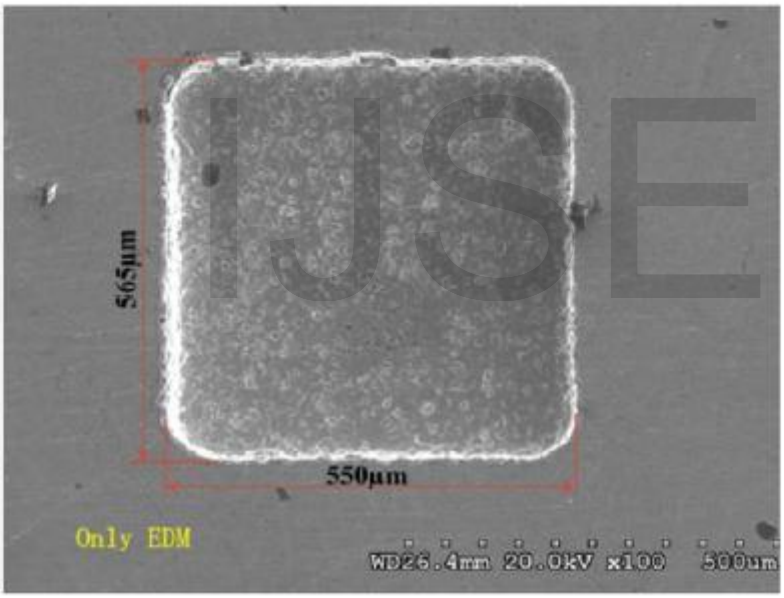
1. Work-piece-almost all the conductive material can be worked by EDM.
2. Tool Electrode-depended on shape of cavity.
3. Dielectric fluid- Electrode & wokpiece submersed into the dielectric fluid.
4. Servo system-The servo system is commanded by signals from gap voltage sensor system in the power supply and control the feed of electrode & work-piece to precisely match the rate of material removal.
5. Power supply-The power supply is an important part of any EDM system. It transform the alternating current from the main utility supply into the pulse direct current (DC) required to produce the spark discharge at the machining gap.
6. DC pulse generator- The DC pulse generator is responsible for supplying pulses at a certain voltage and current for specific amount of time.

The detailed explanations of these components are elaborated below:
1. Workpiece materials: various component can be machined using µ EDM. The various materials machined using µ-EDM found in literature are copper (Raju L et al(2014),(Leera R et al (2016)titanium alloy Ti-6Al-4V (Tiwary AP, Int J Adv Manuf Technol, 2015; 76:151-160.)(Liao et al (2003), SK3 carbon tool steel (Prohaszka et al(1996)SS304 (Pandey et al (2014).)(Natarajan et al(2015), high nickel alloys (Liu HS et al(2005.), tungsten carbide (Hyun-Seok TAK et al(2009). ceramics (Schubert A et al (2013)(Kun LIU et al, Micro electrical discharge machining of ceramic materials and composites; Thesis, Chapter 2 pg 60.).
2. Tool materials: Selection of tool in µ-EDM is a critical factor, as the accuracy and shape of the micro feature machined largely depends on the tool. Tungsten electrodes (Ali MY et al (2009)(Maity KP et al (2012) and tungsten carbide electrodes (Meena VK et al(2012).Lin YC et al (2012)(Jahan MP et al (2009). are the preferred tool materials in µ-EDM. To complement this widely used expensive material, cost effective materials namely brass (Natarajan N et al(2015.), copper((Raju L et al(2014)(Prihandana GS et al (2009), graphite and stainless steel are also tried as tool electrodes.
3.)Dielectric fluids:dielectric fluids are deionized water (Pradhan BB et al (2008)and kerosene (Maity KP et al(2012), (Lin YC et al (2012) .Total EDM 3 oil (Natarajan N et al (2015), hydro carbide dielectric liquids etc. Researchers have added micro molybdenum di-sulphide (µ-MoS2) powder in dielectric fluid and using ultrasonic vibration during µ-EDM processes to improve surface finish and MRR (Maity KP et al (2012)
4. Pulse generators: The commonly used pulse generators in µ-EDM are RC type, transistor-type and transistortype iso-pulse generators. In RC type of generators, the capacitor stores the energy and this energy is discharged during the machining process. Whereas in transistor type pulse generators, the capacitor is replaced by a transistor which switches the pulses to generate rectangular pulses between 0V and 60 V, supply voltage. RC type generators are preferred to transistor type because of high discharge frequency and low discharge energy (Leera R et al 2016). In most cases, transistor-type generator has been used to supply the discharge energy which is good for conventional EDM (Han F et al (2004). Jahan (Hyun-Seok TAK et al(2009). studied, RC-type circuit could be more suitable for fabricating microstructures in tungsten carbide, where accuracy and surface finish are of prime importance.
5. Tool feed mechanisms: For interrupted machining the gap between the tool electrode and the workpiece electrode should be maintained constant. The function of tool feed mechanism is to raise or lower the tool by sensing the voltage fluctuations in the inter electrode gap, so that a constant inter electrode gap is maintained. Servo feed control mechanism is used in most of the setups (Han F et al(2004). Whereas some researchers used different technology based micro actuators to impart the tool movements and these have proved to be more efficient compared to the conventional servo controlled tool feed mechanisms. (Han et al, (2007) proposed a new servo control tool feed mechanism that senses the average gap voltage and uses it as the feedback signal to control the feed, so that the electrode gap is maintained constant. Mahendran S et al. (Mahendran S et al (2011) developed a µ-EDM system with directly mounted APA 400MML Actuator as the tool feed mechanism. (Li et al(2002)) have proposed an inchworm type micro feeding mechanism and direct drive method (Mahendran S et al(2011) based on piezoelectric actuation were also proposed and elaborated.(Leera et al(2014) developed a µ-EDM system with a piezo-actuated tool feed mechanism to maintain a constant gap between the electrodes.
Effect of machining voltage on machining performance To investigate the effect of machining voltage in micro-ECM finishing process on the machining performance, it was set at 8 V, 9 V and 10 V respectively. The initial bottom machining gap between

Table 1
Basic machining condition in micro-EDM.

Open voltage	250 V
Servo reference voltage	180 V
Discharge current	0.21 A
Discharge duration	5 µs
Pulse interval time	10 µs
Capacitance	(1000 pF) 71
Polarity Positive	
Diameter of electrode	Ø 0.11 mm
Rotation of electrode	2000 rpm

electrode and workpiece is 10 µm, and the tool feed rate is 10 µm/s. The machining time of micro-EDM is 80 min. The depth of EDM finished square cavity is 0.185 mm. The length and width of cavity after micro-EDM roughing is 0.55 mm and 0.565 mm. And the objective width of the square cavity is 0.5 mm and 0.2 mm in depth. The diameter of the electrode is 0.11 mm. So the micro-EDM single side discharge gap is about 25µm.(Z. Zeng et al (2012). Fig. 3 shows the SEM photos of micro-EDM .



Conclusion: The detailed review study on different process parameter used in micro –EDM shows its utility in micro-machining applications .

Refrences:

1. Bhardwaj et al (2013a). *Surface roughness (R_a) prediction model for turning of AISI 1019 steel using response surface methodology and Box–Cox transformation" Proceedings of the Institution of Mechanical Engineers.Part B: Journal of Engineering Manufacture,* 228, **223-232.**
.
2. Leera Raju Hiremath S (2015), *Global Colloquium in Recent Advancement and Effectual Researches in Engineering, Science and Technology,* **1281 – 1288**).

3. Kanlayasiri K, Boonmung S(2007),*Effect of Wire EDM machining variable on surface roughness of newly developed DC53 die steel*.Journal of Material Processing Technology, **459-464**

4. Tsai.k,Wang P(2001) *Predictions on surface finish in electrical discharge machining based upon neural network models International Journal of Machine Tools & Manufacture, Vol. 41,2001*, **1385–1403.**

5. Choudhary S,Jadoun R(2014) *Current advance research development in Electric discharge machinin*g ,International Journal of Research in Advent Technology, Vol.2, March 2014, **2321-9637**

6. Raju L Singaperumal M(2016*), A State-of-the-art Review on Micro Electro-discharge Machining,*Applied Mechanics and Materials, 2014; **592-594**

7. Leera R ,Hiremath S(2014), *A State-of-the-art Review on Micro Electro-discharge Machining.* Proceedings of the International Conference on Materials,2016, **507**

8. Tiwary AP ,Bhattacharya B (2015), *A State-of-the-art Review on Micro Electro-discharge Machining*.Int J Adv Manuf Technol, 2015; 76:**151-160.**

9. Meena VK Azad M (2012).*Grey relational analysis of micro EDM machining of Ti-6Al-4V alloy*. Materials and Manufacturing Processes,. 2012, 27: **973-977.**

10. Pandey AK et al (2014).*Optimization of Process Parameter in Micro Electrical discharge Machining*. International Journal of Scientific and Research Publications 2014; 4: Issue 9.

11. Natarajan N et al(2015). *Experimental investigations on the microhole machining of 304 stainless steel by micro-EDM process* ,Int J Adv Manuf Technol. 2015; 77:**1741-1750.),**

12. Liu HS et al(2005).*A study on the characterization of high nickel alloy micro-holes using micro-EDM and their applications*. Materials Processing Technology 2005; 169: **418-426.**

13. Hyun-Seok TAK et al(2009).*Optimization of Process parameter in micro EDM Transactions of non-ferrous materials* Society of China 2009;19 **s114-s118.)**

14. Schubert A et al (2013*) Micro-EDM milling of electrically non-conducting zirconia ceramics,* Procedia 2013; CIRP 6: **297-302.)**

15. N LIU et al (2008). Micro electrical discharge machining of ceramic materials and composites; Thesis, Chapter 2 pg 60.)

16. Ali M et al (2009), *Fabrication of microfluidic channel using micro end milling and micro electrical discharge milling*.International Journal of Mechanical and Materials Engineering (IJMME) 2009; 4 : 1, **93-97**

17. Maity KP et al(2012). *An optimisation of micro-EDM operation for fabrication of micro-hole* Int J Adv Manuf Technol 2012; 61:**1221-1229**

18. Han F et al (2004). *Micro Electrical Discharge Machining of Tungsten Carbide with Ultra-Short Pulse*.Precis. Eng. 2004; 28: **378-385).**

19. Han et al(2007). *Basic study on pulse generator for micro-EDM*. The International Journal of Advanced Manufacturing Technology 2007; 33: **474-479**)

20. Mahendran S et al(2011). *Development of Micro EDM* with *Directly Mounted APA 400 MML Actuator as Tool Feed Mechanism* Advanced Materials Research 2011; 314-316: **1811-1817**

21. Prihandana GS et al(2009). *Effect of low-frequency vibration on workpiece in EDM processes.* International Journal of Machine Tools & Manufacture 2009; 49: **1035-1041**

22. Z. Zeng et al (2012). *A study of micro-EDM and micro-ECM combined milling for 3D metallic micro-structures*. Precision Engineering *36 (2012)* **500– 509)**