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EXPERIMENTAL INVESTIGATION OF ELECTRO CHEMICAL MICRO MACHINING WITH ARTIFICAL INTELLIGENCE

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ABSTRACT

Electrochemical Micro Machining (ECMM) and Electric Discharge Micro Machining (EDMM) processes have high potential when applied in micro regiment for good accuracy and shape reproduction in industries. But they have a limitation that only electrically conducting materials can be machined by them. To overcome this limitation in production, a combination of ECMM and EDMM processes has been conceived, and it is known as electrochemical spark micro machining process‖ (ECSMM) electro chemical discharge machining process (ECDM). Electro Chemical Discharge Machining (ECDM) is a controlled metal-removal process which is used to remove the metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to erode (cut) the work piece to produce the finished part to the desired shape and size. There are various Electro Chemical Discharge Machining (ECDM) process parameters (variables) on which the machining performances depends such as these parameters are polarity, peak current, pulse on time, pulse off time, flushing pressure, Voltage and Concentration. This paper reviews the vast array of research work carried out within past decades for the development of ECDM.

Keywords: Electrical Chemical discharge machining, ECDM parameters, machining characteristic.

1. INRODUCTION

Electro chemical discharge machining (ECDM) is Non conventional machining process which is used for micro fabrication. The principle of Electro chemical discharge machining is to use the eroding effect of controlled electro Chemical discharges machining on the electrodes. The metal-removal process is performed by applying a pulsating (OFF/ON) electrical charge of high-frequency current through the electrode to the work piece. This erodes very small pieces of metal from the work piece at a controlled rate. It is a thermal erosion process. The sparks are created in a dielectric liquid generally oil or water, between the work piece and an electrode, which can be considered as the cutting tool. There is no mechanical contact between the electrodes during the whole process. Since erosion is produced by electrical discharge process, both electrode and work piece have to be electrically conductive. Electro chemical spark machining (ECSM) is also a hybrid machining process which is combination of Electrochemical machining (ECM) & Electro discharge machining (EDM) which is also known as, Electrochemical Engraving, Electrochemical Discharge Machining etc.

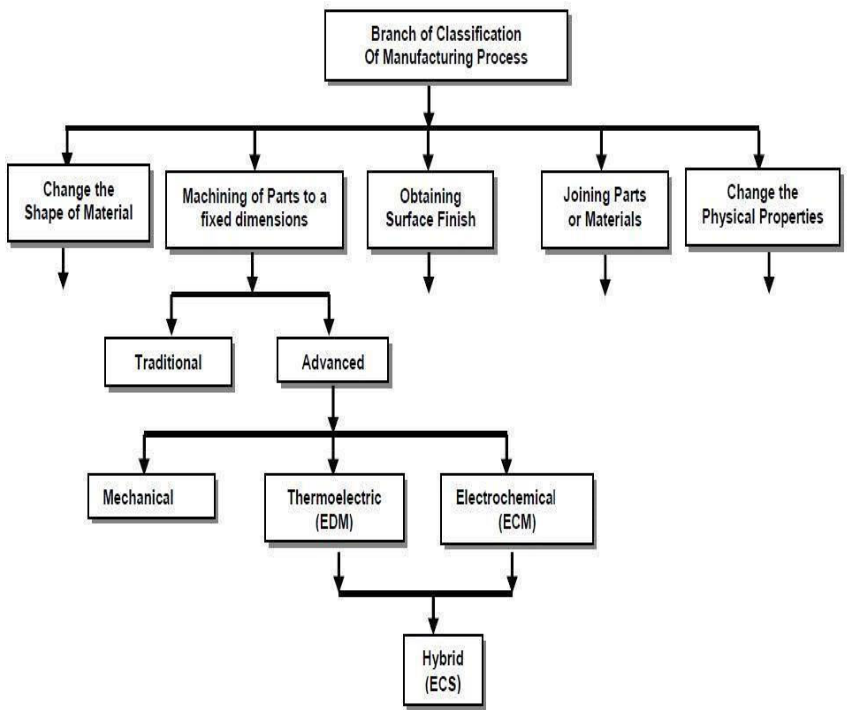
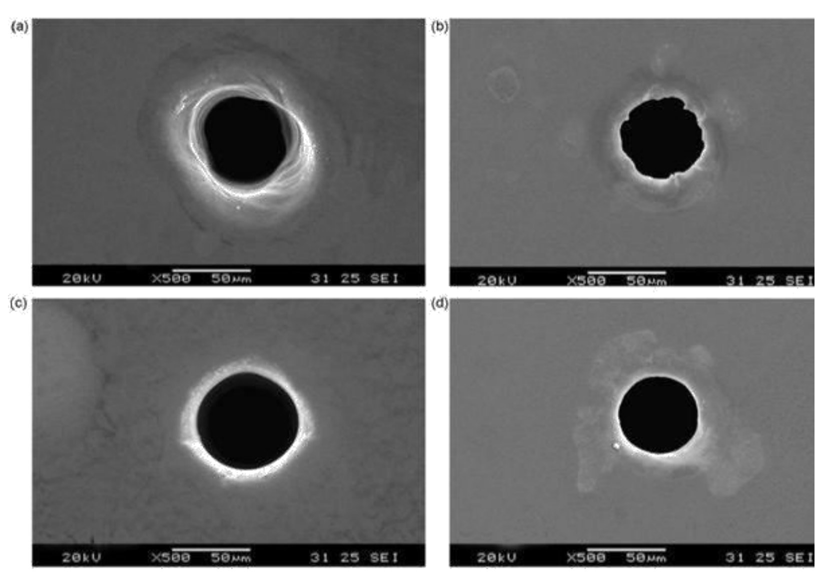


Figure 1: Evolvement of ECS (Branch in the Classification Tree of Manufacturing Process)



Fig,2 a) and (b) Hole entrance and exit drilled at 35V[3], (c) and (d) Hole entrance and exit drilled at 30V[3]

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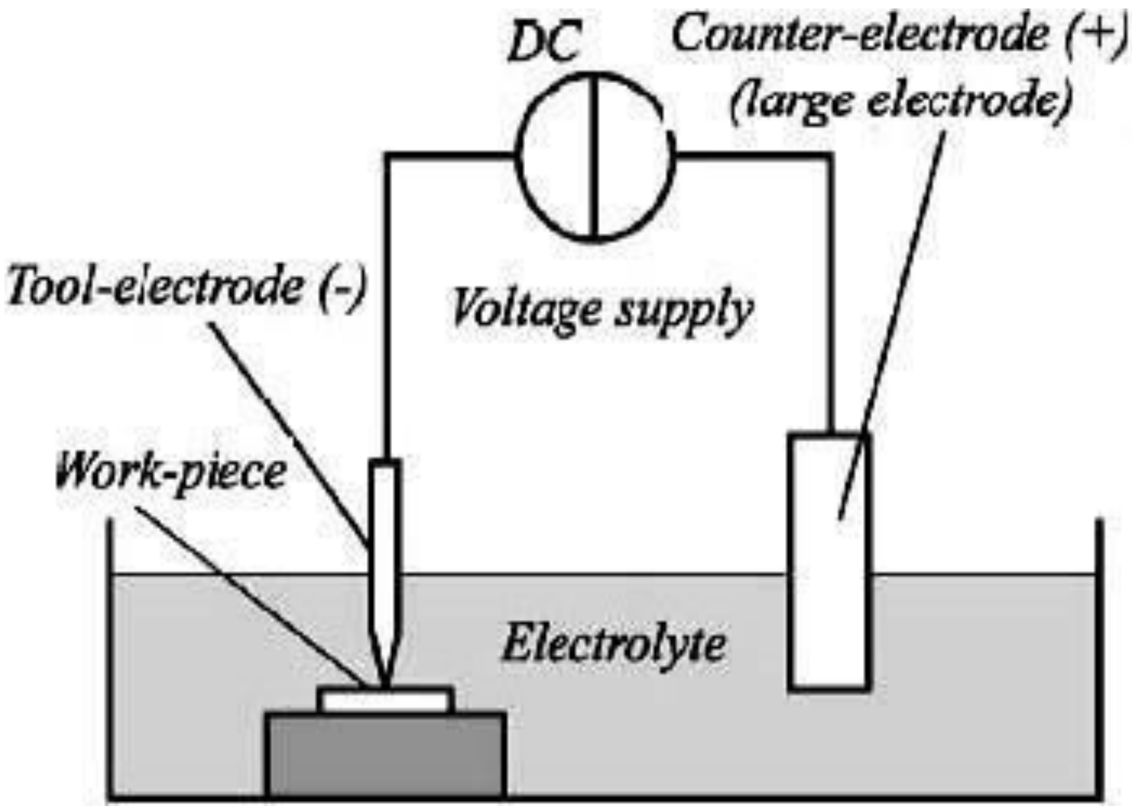


Fig.3 Schematic of diagram ECSM

2. Mechanism of generation of spark in electrolyte

(a) Reactions at anode and electrolyte interface

The reactions of electrochemical type at electrolyte – anode border are reason for production of oxygen and dissolution of anode.

$Cu \rightarrow Cu^{2+} + 2e^-$

$2H_2O \rightarrow O_2\uparrow + 4H^+ + 4e^-$

Here, oxygen gas evolves at the anode sparking occurs across the oxygen gas bubble at the interface of the anode and electrolyte and oxygen gas develops at the anode.

(b) Reactions at cathode and electrolyte interface

Following electrochemical reactions take place at electrolyte interface – cathode, and also reason for production of hydrogen gas.

$Cu_2^{+} + 2e^{-} \rightarrow Cu$

$2H^{+} + 2e^{-} \rightarrow H_2\uparrow$

$Na^{+} + e^{-} \rightarrow Na$

$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$

$2H_2O + 2e^{-} \rightarrow H_2\uparrow + 2OH^{-}$

Hydrogen gas produced at the cathode causes sparking across the bubbles between the electrolyte and cathode. In ECSM process generally two electrodes are largely different in size. Machining may takes place at cathode and anode. The electrode which is used as tool is called active electrode and which is small in size compared to another electrode, which is called as auxiliary electrode. Work piece is kept near to active electrode. Here, voltage applied is also large. Due to small shape at active electrode there is large current density so large amount of gas is generated there.

This gas is nonconductive in nature so this gas film acts as high resistance for electric current so ohmic heating also takes place & more number of gas bubbles are generated this gas is passivity active electrode. As applied voltage is above break down voltage of gas film there is occurrence of spark. Due to this spark gas layer break down takes place & again electrochemical reaction starts. This process continues. Generally power applied in pulsed form of micro second range. This process is shown by operation flow of Electro chemical spark machining.

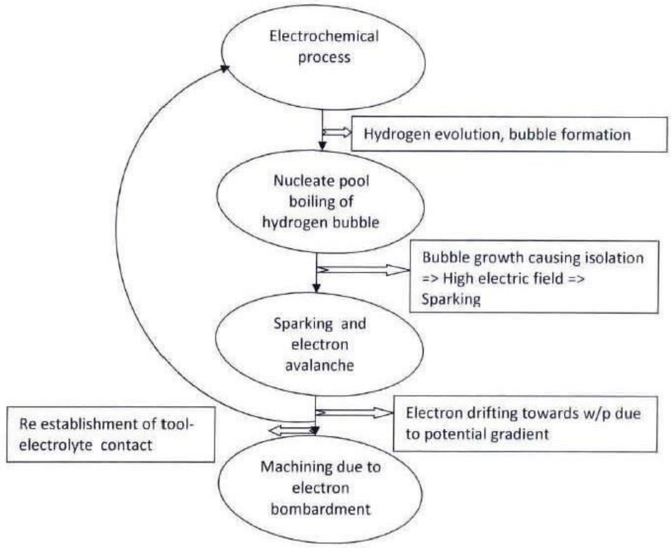


Figure 4 Operational flow of ECSM process showing intermediate processes

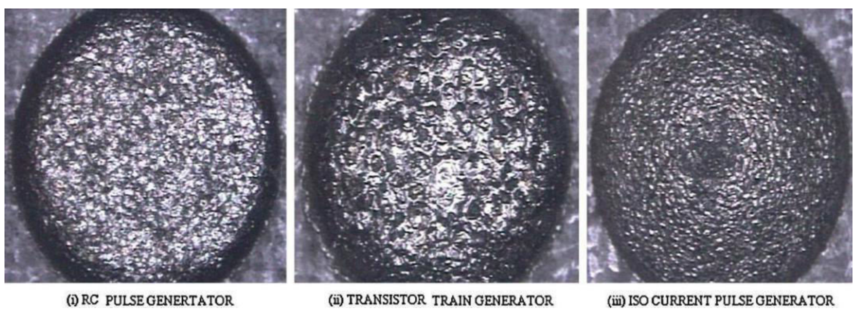


Fig. 5 – Surface topography of machined surface using different pulse generators.

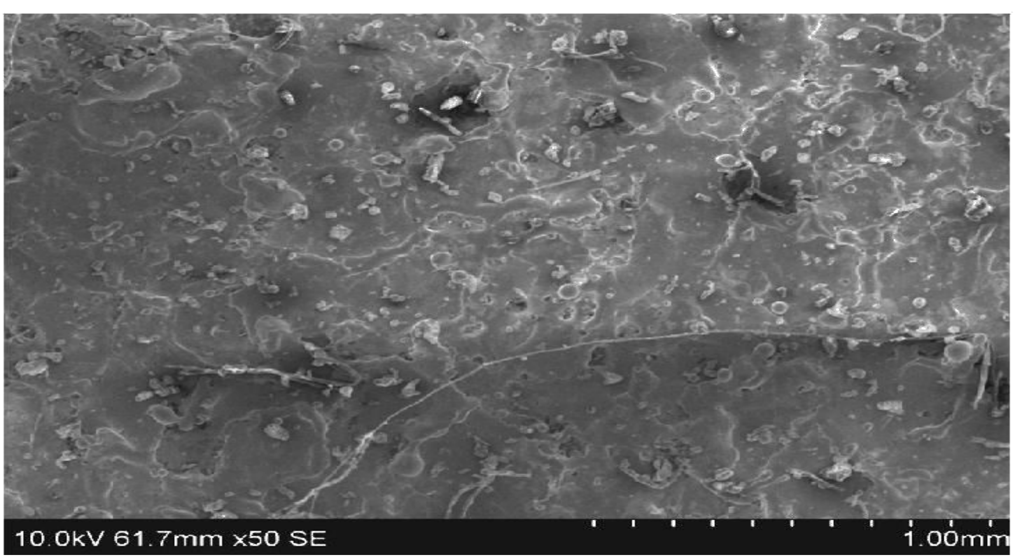


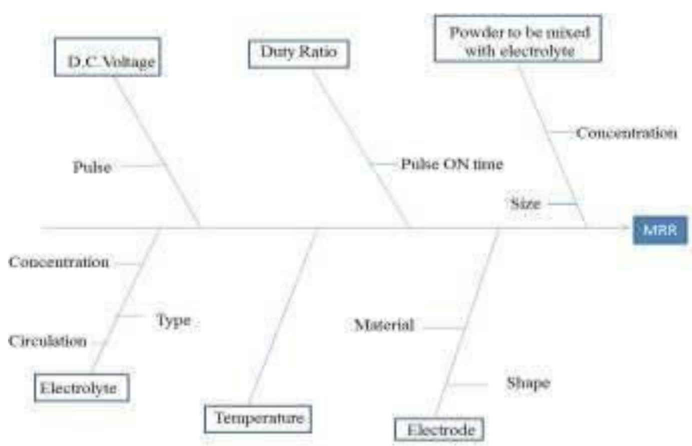
Fig. 6 – SEM images of surface using EDM process

Electro chemical spark machining basically two types. First when cathode is used as electrode then it is called as ECSM direct polarity (ECDP) and when anode is used as tool then it is called as ECSM reversed polarity (ECRP). In both case work piece to be machined is kept near active electrode. Following table compare ECDP & ECRP.

	ECDP	ECRP
Cathode	Active Electrode (small Size)	Auxiliary electrode (large in size)
Anode	Auxiliary electrode (large in size)	Active electrode (small in size)
Surface finish	Better than ECRP	Good
Passive gas	Hydrogen	Oxygen
MRR	Good	Better than ECDP

3 MAJOR PARAMETERS OF ECDM

EDM Parameters mainly classified into two categories.



1. Process Parameters 2. Performance Parameters

1. Parameters

The process parameters in EDM are used to control the performance measures of the machining process. Process parameters are generally controllable machining input factors that determine the conditions in which machining is carried out. These machining conditions will affect the process performance result, which are gauged using various performance measures.

A. Electrical Parameters

1. Polarity
2. Discharge voltage
3. Gap Voltage
4. Peak Current
5. Average Current
6. Pulse on Time
7. Pulse off time
8. Pulse Frequency
9. Pulse waveform
10. Electrode Gap
11. Duty Factor

B. Non-Electrical Parameters

1. Electrode lifts time
2. Working Time
3. Nozzle flushing
4. Gain
5. Type of Dielectric

C. Powder Based Parameters

1. Powder type
2. Powder concentration 3.Powder size
4. Powder conductivity
5. Powder density

D. Electrode Based Parameters

1. Electrode material 2. Electrode size
3. Electrode shape

2. Performance Parameters- These parameters measure the various process performances of EDM results.

1. MRR
2. SR
3. Tool wear rate

4. Wear ratio
5. SQ
6. Recast layer thickness

4. Research Progress in Electro chemical discharge machining

Author/year	Process parameters	Tool electrode	Work piece
Ming, Q.Y.et al.(1995)	Current pulse width, pulse interval, Additives powder concentration	Copper	High carbon steel
Tezeng Y.F.et al.(2001)	Aluminum chromium copper & silicon carbide powder concentration	Copper	SKD-11
Klocke, F. et al.(2004)	Polanity voltage pulse duration duty cycle concentration of Al & si powders.	Tungsten electrode	Supper alloy
Tzeng, Y.F. et.al(2005)	Peak current pulse duty cycle powder size, powder concentration of Al, cr,cu, si.	Copper	SKD-11
Kansal H.K. et. Al(2006)	Peak current, Pulse duration, Duty cycle, Concentration of silicon powders.	Copper	H-11 Die steel
Kansal H.K. et.al(2007)	Peak current, Pulse on time, Pulse off time, concentration of powder, Grain & Nozzle.	Copper	AISI D2 Die steel
Singh G. et. Al(2010)	Concentration of aluminum powder and grain size of powder.	Copper eletrode	Hastelloy
Syed & palaniyandi(2012)	Peak current, pulse on time , polarity, concentration of Al	Electrolytic copper	W300 die steel
Ondrej hanzel, Deepak marla, parol, et.al (2017)	Pulse on time, wire speed , dielectric fluid , current.	Copper	Sic-composites.

5. Optimization of EDM process

In EDM most of the research works have been carried out to optimize the electrical process parameters. Wykes and Marafona described an investigation into the optimization of material removal rate in the EDM process with copper tungsten tool electrode [J.marafona, C. waykes,et.al]. From thIS experimental results, it has been proved that large current intensity would result in higher material removal rate. Matoorian et al. presented the application of the Taguchi robust design methods to optimize the precision and accuracy of the Electro discharge machining process for machining of precise cylindrical forms on hard and difficult-to-machine materials [P.matoorian, s.sulaiman, ahmed et.al]. They found that the current intensity of the Electro discharge machining process affects the material removal rate greatly. Muthuramalingam and Mohan developed Taguchi-DEAR methodology based optimization of electrical process parameters [T.mathuramlingam, B.mohan,et.al]. Chen and Tzeng described about the application of the fuzzy logic analysis coupled with Taguchi methods to optimize the precision and accuracy of the high speed electrical discharge machining process [Y.F.Tzeng,F.C, et. al]. The most important factors

affecting the precision and accuracy of the high speed EDM process have been identified as duty cycle and peak current. Kuriakose and Shunmugam developed a multiple regression model to represent relationship between the input and output process variables [S.kuriakosa, m.s. shunmug, et.al]. They have done the multi objective optimization method based on non-dominated sorting genetic algorithm to optimize the EDM process parameters.

6. Conclusion

ECDM is very good process that can be applied to metal, ceramic, composite and non conductive material. It has less MRR but that is advantage during micromachining. Main obstacle to apply ECDM to miniature component is crack near machining. MRR is also dependent on many parameters. To increase reproducibility of ECDM, there is need of research to control over gas film during dynamic conditions of machining. This process has potential to heat treatment also. Comparing to another non conventional process it has less setup cast, so by proper modification it can become practical machining process.

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