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A REVIEW ON PROCESS, EFFECTIVE PARAMETERS AND OPTIMIZATION TECHNIQUES USED IN ELECTRO CHEMICAL DISCHARGE MACHINING (ECDM)

Engineering

KEYWORDS: Electrochemical discharge machining (ECDM), Material removal rate (MRR), Tool wear rate (TWR), Surface finish, Optimization techniques.

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ABSTRACT

Electro Chemical Discharge Machining (ECDM) is an emerging hybrid machining process which has potential to machine hard and brittle non-conducting materials with good surface quality desired by industries. ECDM is a combination of ECM and EDM process in which electrochemical dissolution of the material and thermal erosion by electric discharge that occur between the electrodes. In this current review work, a study of the basic phenomenon of ECDM and then the selection of effective parameters of ECDM has carried out and their corresponding responses like Material Removal Rate (MRR), Tool Wear Rate (TWR) and higher surface finish has been studied. The different prediction and optimization techniques used for control the parameters within the optimization range in different work also reviewed.

INTRODUCTION

Modern machining process plays a vital role in industries those who manufacturing a highly précising components. Now days highly fatigue strength, thermal shock resistance, highly strength to the weight ratio material comes in the market, which is very difficult to machine with conventional machining processes with good surface quality. ECDM is one of the advance hybrid process with the combination of ECM and EDM. This process has great ability to machine non conducting materials [1].In ECDM process gap is controlled with automatic feed mechanism by a low speed stepper motor [2]. The electrical discharge takes place through the electrolyte and plays a vital role [3].The

empirical mathematical model, showing the influence of the parameters on the electrode tool wear, material removal rate and the shape accuracy of the machined hole [4]. The performance of ECDM in terms of MRR, TWR and surface finish is affected by many factors. Relationship between these factors and their responses are highly non-linear and complex in nature. Therefore, it is very difficult to develop a relationship between those factors and the machining performance with conventional mathematical modeling. In this literature review paper, firstly study the basic phenomenon of ECDM explained by various researchers then the effects of different parameters in ECDM process is carried out and the different calculation and the optimized value of their parameter by various optimization techniques has been summarized.

PRINCIPAL OF ECDM

The principle is explained in Fig. 1 [5]. The work piece is dipped in an electrolytic solution and constant DC voltage is applied between tool and the counter-electrode. The tool-electrode is dipped a few millimeters in the electrolytic solution and the counter-electrode is, in general, a large flat plate. The tool-electrode surface is always significantly smaller than the counter-electrode surface (by about a factor of 100). The tool-electrode is generally polarized as a cathode, but the opposite polarization is also possible.

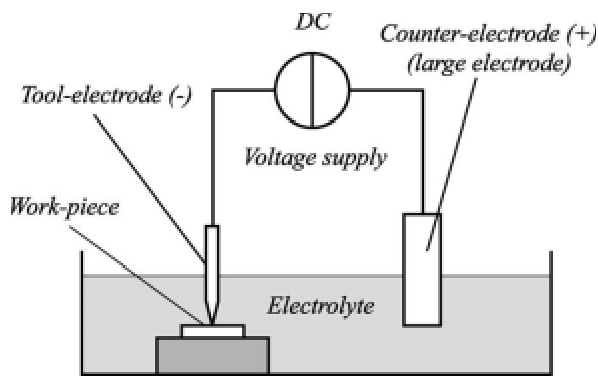

Figure1: Schematics of the ECDM set-up. Two electrodes, dipped into an electrolyte are supplied to a constant DC voltage. The cathode, with the smallest surface, is used as tool to machine the work piece. [5]

When the supply of the voltage is low (lower than a critical value called critical voltage, typically between 20 and 30 V) hydrogen gas bubbles are formed at the tool-electrode and oxygen bubbles at the counter-electrode depending on their polarization and the electrolyte used. When the voltage is increased, the current density also increases and more and more bubbles are formed near the tool electrode and the density of the bubbles and their mean radius increase with increasing current density. When the terminal voltage is increased above the critical voltage, Light emission can be observed in the film i.e. electrical discharges, this is so-called electrochemical discharges, occur between the tool and the electrolyte. Machining is possible if the tool-electrode is in the near vicinity of the workpiece. Typically, the tool-electrode has to be closer than 25 um from the workpiece for machining to take place. However, things are not as simple as they seem. The gas film around the tool-electrode is not always stable. Micro explosions may occur destroying the machined structure locally. During drilling of holes, the local temperature can increase to such an extent, resulting in heat affected zones or even cracking. The various parameters of ECDM for a workpiece and tool combination and their effect on MRR, SF, and TWR have been listed in TABLE 1.

TABLE 1: THE INPUT PARAMETERS AND THEIR EFFECT ON OUTPUT PARAMETERS DURING ECDM

S.No	Workpiece Materials	Input parameters	Tool Materials	Range	Output Parameters			Reported By
					MRR	TWR	SF	
1.	3Dmicrostructures of glass(Pyrex glass)	Electrolyte concen.,Pulse on/off ratio, Appliedvoltage, feed rate in drilling process	Tungsten Carbide used As cathode	Electrolyte(KOH): 30%wtg Pulse voltage:30V Pulse ratio; 1ms/1ms	-	-	Poor surface finish when voltage is high	Xuan Doan cao Hyun [6]
2	Quartz	Open voltage, Gap voltage, Peak current, Duty floor, Rotational speed	Auxiliary electrode(gr aphite)	Open voltage(v):150 Gap voltage(V):100 Peak current(A):3 Duty Factor:50	High material removal rate is achieved	Cylindrical electo de shows tool wear marks	Spheric al electrod e have a dvantage in enhancing the shape accuracy of the microthrough hole	Chengyang-Jung [7]
3	Pyrex glass composed mainly SiO2(83 %), B2O3(10%), Al2O3(3%)	Applied Voltage, Electrolyt econcen, Rotational speed	Anode Auxiliary electrode(gr aphite) Cathode (Tungsten carbide)	Applied Voltage(V):30-45, Electrolyte conce.:6M(KOH), Rotational speed:500rpm	High material removal rate is achieved	-	Smooth surface finish	Chihchengc haochung [8]
4.	Optical glass and Quartz bars	Applied voltage Electrolyt e concen.	-	Applied voltage (V):45-90, Electrolyte concen: 5M,	MRR can be obtained using the duty factor0.53,f=200 Hz,MRR= 0.06mm^3/min	-	Less surface roughness and better transparency (Ra)=3. 5μm	W.Y Peng and Y.S Liao [9]
5.	Borosilic ate Glass	Applied Voltage, Peak Current Electrolyte Conc. ,Graphite conc.		Applied Voltage (V):35, Peak Current(A):1.1 Electrolyte Conc.(wgt%):30 ,Graphite powdercon.:.5-2wgt%	MRR improved using rotational tool	-	Surface roughe ss Ra=1.4	Min-Seop Han, Byung-Kwon Min , Sang Jo Lee [10]
6	Quartz	Applied Voltage, Duty factor, Surfactant, Electrolyte concentration.	Tungsten Electrode	Applied Voltage(V):50-70, duty factor:0.75, Electrolyte concen.:6M(KOH)	Lower surfactant gives low machining	-	Better surface Quality but little oversize d holes are drilled with higher engraving speed	Y.S Laio L.C Wu,W. Y Peng [11]
7.	Silicon nitride ceramics	Applied Voltage, Electrolyte. Concen. Interelectrode Gap	Stainless Steel	Applied Voltage(V):50-70, Electrolyte Concen.(wgt):10-30 Inter-electrode Gap(mm):20-40	Effective MMR on the combination of 80V and 25%NaOH	-	-	Bhattac harya [12]
8.	Metal matrix composite Aluminum alloy,20%Sic	Current Voltage Pulse duration	Cylindrical steel tool	Current:0.5-5(A) Voltage:20-120(V) Pulse duration:4-400(μs)	Increase in MRR.	-	Surface finish is poor	Lui [13]
9	Kevlar fiber epoxy, glass fiber epoxy	Applied Voltage, Electrolyte. Concen.		Voltage: 65-80 (V) Electrolytic-conductance: 0.16-0.18 (S, mhocm-1)	MRR found to be >10 mg/min at 0.19 (S)	-	-	Tandon et al. [14]
10	Epoxy glass + Fiber composite	Applied Voltage, Electrolyte. Concen. Interelectrode Gap	IS-3748/T35Cr5Mo1V30	Voltage: 55-70 V Elec. Con. : 65-80, wt% Anode to cathode gap : 70-200 (mm)	MRR : 1-2.9 (mg/min),	-	-	Manna And Narang [15]
11	Brittle Soda Lime	Applied Voltage, Electrolyte. Concen. Interelectrode Gap)	Copper	Voltage:40-60 V Elec. Con. : 20-40, wt% Anode to cathode gap : 20-40 (mm)	MRR: Higher MRR with KOH as compared to H2SO4	-	-	M.L Harugade al. [16]

Legend: MRR = Material removal rate, MR = Material removal, TWR = Tool wear rate, TW = Tool wear, M/c =Machining, Dia = diameter, V = Voltage, Vc = Critical Voltage, g/l = grams/litre, A = Ampere, Hz =Hertz, Elec.Con. = Electrolyte concentration, mm = millimeter, SR = Surface roughness, mN = 10-3 Newton, μRa =Roughness average in microns, Rw =Energy partition, MMC = Metal matrix composite, SiC = Silicon carbide, , S= seconds.

OPTIMIZATION OF PARAMETERS OF ECDM

Electrochemical discharge machining is a latest non conventional machining process to produce high quality precise and very complex products. These advanced machining processes involve large number of input parameters which may affect the cost and quality of the products. Selection of optimum machining parameters is very important to satisfy all the conflicting objectives of the process. The optimized value of influencing parameters with applied optimization techniques has been listed in TABLE 2.

TABLE 2: OPTIMIZATION TECHNIQUES AND INFLUENCING INPUT PARAMETERS OF ECDM:

S.No	Optimization Techniques	Input Parameters	Levels	Response Parameters	Optimum Value of Input Parameters	Influencing Parameters	Reported By
1.	Standard orthogonal Array L9	Applied voltage, Electrolyte concentration, Inter electrode gap	THREE	Material Removal,Siganl to noise ratio	Applied voltage (50V) Electrolyte Conc.(15%), Inter electrode gap(30mm)	Applied voltage 62.76%	B.Doloi all [17]
2.	TLBO(Teacher learning Based optimization)	Applied voltage, Electrolyte concentration, Inter electrode gap	-	Radial overcut, Material Removal rate,Heat effected zone	Applied voltage (50V) Electrolyte Conc.(30%), Inter electrode gap(20mm)	Applied voltage	RV Rao. 2011[18]
3.	Taguchi's standard L-4 orthogonal array and Anova	Applied voltage, Electrolyte concentration, Work feed rate	TWO	Material Removal, Tool Wear	Applied voltage (80V) Electrolyte Conc.(50g/l), Work feed rate(6mm/min)	Applied voltage 94.07%	Jawalkar, [19]
4.	Genetic Algorithm	Applied voltage, Electrolyte concentration, Inter electrode gap	FIVE	Radial overcut,Heat effected zone	Radial overcut minimum at Applied voltage (50V) Electrolyte Conc.(20g/l), Inter electrode gap(20mm)	-	Ruben all [20]
5.	Taguchi Orthogonal array L9	Applied voltage, Electrolyte concentration, Inter electrode gap	THREE	Tool wear rate, Material removal rate	Applied voltage (60V) Electrolyte Conc.(30%), Inter electrode gap(0.3mm)	, Inter electrode gap 47.05%	Sathisha all.[21]
6.	Taguchi method L16(45) Orthogonal array and ANOVA	Applied voltage, Electrolyte concentration,Electrlyte flow,Bare tool tip length	FOUR	Material removal rate,AVDRO	Applied voltage(20V), Electrolyte concentration(75g/l),Electrlyte flow(150l/hr),Bare tool tip length(1.5)	Applied voltage 53.88%	Chigal all [2]
7.	Standard orthogonal Array L9 and ANOVA	Applied voltage, Electrolyte concentration, Inter electrode gap	THREE	Material Removal,Siganl to noise ratio	Applied voltage (60V) Electrolyte Conc.(20g/l), Inter electrode gap(20mm)	Applied voltage 51.77%	Harugade all [16]
8.	Genetic Algorithm and PSO(RBFNN)	Applied voltage, Electrolyte concentration, Inter electrode gap	TWO	Tool wear rate, Material removal rate,Heat effected zone	Applied voltage (70V) Electrolyte Conc.(30%), Inter electrode gap(20mm)	PSO(RBFNN is better technique for same conditions then GA(RBFNN)	K.Shanmukhi all [22]

CONCLUSION

The following facts can be concluded:

1. It was found from the researches that the most critical parameters of ECDM which influence the MRR, TWR and surface finish was Electrolyte concentration, Electrolyte temperature, Machining voltage, Machining depth.

2. Applied voltage is the most influential parameter for Material removal rate.

3. Electrolyte concentration the secondary parameter affecting the MRR and Tool wear rate.

4. Machining depth decrease the MRR but it can be countered by the shape of the tool-electrode.

5. To find optimal process parameters to set in the ECDM is necessary to achieve best quality outputs.

6. The optimization techniques are required to known the optimized value of parameters for better performance of ECDM.

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