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A Review on Effective Parameters of Electro Chemical Machining

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Abstract— **Electrochemical discharge machining (ECDM) is one of the hybrid advance machining processes which have potential to machine advance materials with good surface quality desired by Industries. The selection of parameter for higher Material removal rate, higher Surface finish and minimum Tool wear Rate is very essential during ECDM. In this present review Paper, a study of the effective Parameters of ECDM has been carried out with their specific role in Material removal; Surface Finish and Tool wear Rate. The optimized range of parameters by different optimizing techniques has been summarized**

Keywords- Optimization Techniques, Electrochemical Discharge Machining, Material Removal Rate, Surface Finish, Tool Wear Rate

I. INTRODUCTION

I. INTRODUCTION

Advanced Machining Processes came into need in the advanced industries like nuclear reactors, aeronautics, automobiles, therefore the demand increases for the material which have high strength temperature resistant (HSTR) alloys. To enhanced the capabilities of the machining processes, two or more than two machining process are combined to take advantage of the worthiness of the constituent processes are called hybrid processes [1]. Electrochemical machining process is also one of the hybrid processes which combine the Electro Chemical Machining (ECM) and Electric Discharge Machining (EDM) process together. It can be used for machining electrically non-conductive advanced engineering materials such as glass and ceramics [2]. Electrochemical discharge machining process are mainly for micro-machining and scribing hard and brittle non-conductive materials
such as glass (mainly Pyrex, plexi and optical) ceramic, refractory bricks, quartz and composite materials which examines the influence of electrolyte concentration, voltage and tool tip geometry on material removal rate and condition of machined surface [3-4].In ECDM process gap is controlled with automatic feed mechanism by a low speed motor [5]. The KOH electrolyte gives a smaller machining gas than a NaOH solution which results in the increases of Material Removal Rate [6]. The empirical mathematical model, showing the influence of the process parameters on the electrode tool wear, MRR and the shape accuracy of the machined hole [7].The EDM and ECDM process are similar regarding the formation of craters on the work piece, along the re-casting effects which caused by the sparking actions [8] . The process parameters were applied voltage, electrolyte concentration and the inter-electrode gap and the effective parameters were minimum radial overcut (ROC) and minimum heat affected zone (HAZ) [17]. Hybrid machining processes (HMPs) are developed to enhance the material removal rate (MRR) increases the capabilities of the constituent process. In the present review paper, the various Input parameters with their effect on Material Removal Rate, Surface Finish (SF) and Tool Wear Rate (TWR) have been discussed. The optimized value of their parameter by various optimization techniques has been summarized.

II. ECDM PROCESS

The working principle in ECDM process involves the combination of thermal and chemical mechanisms electrically. The two electrodes are immersed in the electrolyte solution which helps in the formation of hydrogen gas and vapour bubbles. The cathode (tool) is chosen with a much smaller surface than the anode (auxiliary electrode). When the D.C voltage supply is applied, electrolysis happens and an insulating layer of gas bubbles are formed at the tool electrode (cathode) and oxygen bubbles at the counter electrode(anode).

When the voltage is increased, the density of sparks increases and more and more bubbles grow, forming a bubbles layer around the electrodes. The nonconducting workpiece is placed at the sparking area and tool always touches the workpiece which iscontrolled by the fixture.

The spark generation results in the material removal from the non-counting material [3-4].The various parameters of ECDM for a workpiece and tool combination and their effect on MRR, SF, and TWRhave been listed in TABLE 1.

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S.NO	WORKPIECE MATERIAL	INPUT PARAMETER	TOOL MATERIAL	RANGE	OUTPUT PARAMETERS			REPORTED BY
					MRR	SF	TWR	
1.	Glass (Pyrex)	Voltage Elec.con Pulse	-	Voltage:20-45V Elec.con:5-40(wt %) Pulse:0-80(μs)	Increases with DC voltage, Elec .temp Depending upon the work piece material.	-	Increases with Voltage	Facio And Wuthric H [9]
2.	Glass (Pyrex)	Voltage Elec.con	Stainless Steel, Tungsten Carbide and Tungsten	Voltage: less than 30V Elec.con:20-40(wt %)	Increases with Use of KOH as electrolyte	Surface roughne Ss up to 39.73 to 45.95 to91.22mm	Least tool Wear in Tungsten Carbide Electrode	Chengkung [6]
3.	3D micro structures of glass (Pyrex glass)	Electrolyte Concen., Pulse on/off Ratio, Applied Voltage ,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 [10]
4.	Quartz	Open voltage, Gap voltage, Peak current, Duty floor, Rotational ,speed	Auxiliary Electrode (graphite)	Open voltage(v):150 Gap voltage(V):100 Peak current(A):3 Duty Factor:50	High material Removal rate is achieved	Spherical electrode have Advantage in Enhancing the Shape accuracy of the microthrough Hole	Cylindrical Electrode Shows tool Wear marks	Chengyang-Jung [11]
5.	Pyrex Glass Compose D mainly Sio2 (83%), B2O3 (10%), Al2O3 (3%)	Applied Voltage, Electrolyte concen, Rotational speed	Anode Auxiliary Electrode (graphite) Cathode (Tungsten Carbide)	Applied Voltage(V): 30-45, Electrolyte Conce.:6M (KOH), Rotational Speed:500rpm	High material Removal rate is achieved	Smooth Surface Finish	-	Chihchengchaochung [12]
6.	Optical Glass and Quartz Bars	Applied Voltage Electrolyte concen.	-	Applied voltage (V):45-90, Electrolyte Concen: 5M,	MRR can be Obtained using the duty Factor0.53, F=200Hz,MRR= 0.06mm^3/min	Less surface Roughness and Better transparency (Ra)=3. 5μm	-	W.Y Peng And Y.S Liao [13]
7.	Borosilic Ate Glass	Applied Voltage, Peak Current Electrolyte Conc. ,Graphite Conc.	-	Applied Voltage(V): 35,Peak Current(A): 1.1Electrolyte Conc.(wgt%): 30,Graphite Powdercon.: .5-2wgt%	MRR improved Using rotational Tool	Surface roughness Ra=1.44μm	-	Min-Seop Han, Byung-Kwon Min , Sang Jo Lee [14]
8.	Quartz	Applied Voltage, Duty factor, Surfactant Electrolyte concen.	Tungsten Electrode	Applied Voltage(V): 50-70, Dutyfactor: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 [15]
9.	Silicon Nitride Ceramics	Applied Voltage, Electrolyte. Concen. Inter -	Stainless Steel	Applied Voltage(V): 50-70, Electrolyte Concen.(wgt):10-30	Effective MMR on the Combination of 80V and 25%naoh	-	-	Bhattacharya [4]

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		electrode Ga		Inter-electrode Gap(mm): 20-40				
10.	Metal Matrix Composite Aluminum Alloy,20 %Sic	Current Voltage Pulse Duration	Cylindrical Steel tool	Current:0.5-5A Voltage: 20-120(V) Pulse duration: 4-400(µs)	Increase in MRR.	Surface finish is Poor	-	Lui [8]

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.

III. OPTIMIZATION OF PARAMETERS OF ECDM

The selection of optimum range of parameters is very necessary for better performance of ECDM. The approach adopted by design of experiment through the taguchi orthogonal array is very popular for solving optimization problems in manufacturing engineering. The ANOVA is also been used successfully in process optimization. It is difficult to solve the third order models hence, based on the second order polynomial equations, some mathematical models correlated the ECDM process parameters while machining nitride ceramic. 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 TECHNIQUE	INPUT PARAMETERS	LEVELS	RESPOENSE PARAMETERS	OPTIMUM VALUES OF INPUT PARAMETERS	INFLUENCIN PARAMETERS	REPORTED BY
1	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 con.(50g/l) Work feed rate(6mm/min)	Applied voltage 94.078%	Jawalkar[3]
2.	standard Orthogonal array(L9) and ANOVA	Applied voltage, Electrolyte concentration, Inter-Electrode gap	Three	Material Removal Rate, Single to noise Ratio	Applied voltage(60V) Electrolyte con.(20g/l), Inter Electrode Gap(20mm)	Applied voltage 51.77%	Hurugede [2]
3.	Taguchi's Orthogonal array L9	Applied voltage, Electrolyte concentration, Inter-Electrode gap	Three	Material Removal,Tool Wear	Applied voltage(60V) Electrolyte con.(30%), Inter-Electrode Gap(0.3mm)	Inter Electrode Gap 47.05%	Sathisha [16]
4	Genetic Algorithm	Applied voltage, Electrolyte concentration, Inter-Electrode gap	Five	Redial overcut, heat effect zone	Redial overcut minimum at applied voltage(50V), Electrolyte concentration (20g/l), Inter-Electrode gap(20mm)	-	Ruben [17]
5	Taguchi's method L16(4^5) Orthogonal array and ANOVA	Applied voltage, Electrolyte concentration, Electrolyte flow. Bare tool tip length	Four	Material Removal Rate, Average Depth of Redial overcut	Applied voltage(20V), Electrolyte concentration(75g /l), Electrolyte flow(150 l/hr). Bare tool tip length(1.5 mm)	Applied voltage 53.88%	Chigal [5]
6	standard Orthogonal array L9	Applied voltage, Electrolyte concentration, Inter Electrode	Three	Material Removal Rate, Single to noise Ratio	Applied voltage(50V) Electrolyte con.(15%), Inter Electrode Gap (30mm)	Applied voltage 62.76%	B.Doloi and Bhattacharyya[18]

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7	TLBO(Teaching Learning Based Optimization)	Applied voltage, Electrolyte concentration, Inter Electrode	-	Material Removal Rate, Redial overcut, Heat effect zone	Applied voltage(50V) Electrolyte con.(30%), Inter Electrode Gap(20mm)	Applied voltage	RV Rao [19]
ANOVA=Analysis of variance,g/l=gram/litre.l/hr=litre/hour							

IV CONCLUSION

It was found in the researches that applied voltage is the most influential parameter for Material removal rate.

Electrolyte concentration the secondary parameter affecting the MRR and Tool wear. The optimization techniques are required to known the optimized value of parameter for better performance of ECDM. The ECDM has capability to provide better results but selection and optimization of parameters is necessary.

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