Improve the Material Removal Rate of Electrochemical Grinding on Monel 400 Using RSM

P. Mohan, G. Vinothkumar, M. Thirulogachandar, B. Manimaran, P. Venkatesan,

Abstract*: Electrochemical grinding is combination of electrochemical machining and mechanical grinding process.in this process 90%-98% percentage of material are removed by electrochemical machining, only 3%-5% of materials can only remove by mechanical grinding process. Faradays law of electrolysis (or) reverse electroplating act as a basic principle for this ECG process. This ECG has various advantages than other machining process for high strength materials .low induvial stress, large depth of cut .here Monel 400 alloy take base material ,its Ni-Cu alloy so it's have very high level corrosion resistance, so it's used in marine engineering ,heat exchanger. Here silicon carbide abrasive insulated brass grinding wheel used instead of copper bonded diamond wheel. Voltage, electrolyte concentration, electrolyte flowrate take are the parameters of this process. Three factors and two levels of RSM methodology takes for optimization. The Analysis of variance (ANOVA) has been delivers the variation between the parameters performed to develop mathematical model. The parameters high voltage and concentration of electrolyte to produce maximum material removal rate.

***Index Terms*: Ecg, Abrasive Brass wheel, Rsm .Monel 400.**

I. INTRODUCTION

Resistant to seawater is a main property of Monel 400 the corrosion resistance of Monel 400 very high compare than other high strength materials. The material have good level of inherent characteristics so it's used in major key mechanical component's [1].The Monel 400 have very good thermal conductivity property and its chemical reaction between other materials is very less and also it have low level of elastic modulus, Electrochemical grinding (ECG) combination of electrochemical machining and grinding process so it's called as hybrid machining process [2- 3]. Electrochemical process have numerous advantages than other process high depth of cut and low induced stress level so its increase the grinding wheel life. Electrochemical grinding is used to machining high strength material, alloys and carbides for improve machining properties material removal rate and surface roughness [4-6]. Now a days mostly concentrate on MRR (Material Removal Rate), machining accuracy, precision, surface roughness and grinding wheel life. Over this paper we are taken Monel 400 material as a workpiece material and silicon carbide abrasive coated brass grinding wheel taken as a tool for this electrochemical grinding process to produce better material removal rate with better surface roughness,

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***** Correspondence Author
P.Mohan*, Department Of Mechanical Engineering, M.A.M College of Engineering, Trichy, Tamilnadu, India.
G.Vinothkumar, Department Of Mechanical Engineering, M.A.M College of Engineering, Trichy, Tamilnadu, India.
M.Thirulogachandar, Department Of Mechanical Engineering, M.A.M College of Engineering, Trichy, Tamilnadu, India.

II. EXPERIMENTAL SETUP

Fig. 1 is 3D design model of the electrochemical grinding machine .the silicon carbide abrasive coated brass grinding wheel attached to a rotating spindle ,the spindle directly connected the small AC motor and the speed is controlled by a speed regulator .the feed motion of tool has been controlled by a PLC circuit. The inter electrode gap between tool and wheel controlled by PLC circuit controller manually. The AC to DC transformer is used to convert voltage and the positive charge (ANODE) is connected to workpiece (Monel 400),the negative charge is connected to silicon carbide abrasive coated Brass grinding wheel .NaCl taken as electrolyte ,the separate water pump used to feed the electrolyte ,is flow between wheel and workpiece .the electrolyte flow controlled by manually. The setup design is electrochemical grinding machine setup, it's a simple setup to operate and handling. The 3D model of ECG test apparatus is shown in below of the Fig. 2.1.

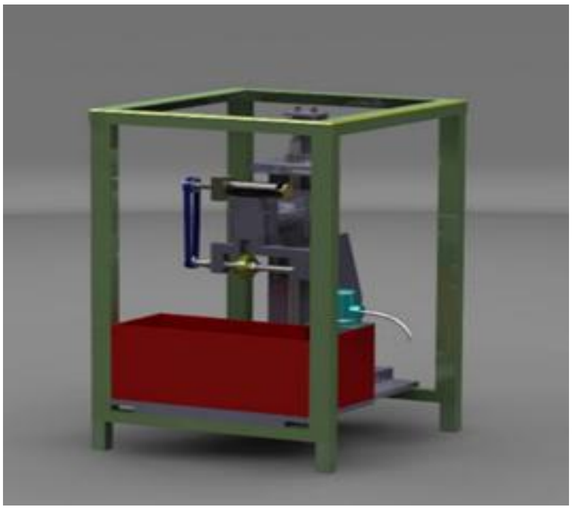

Fig. 2.1 3D Model of Experimental Setup

This is the prototype design of the electrochemical grinding machine.

2.1Tool design

In this process the electrochemical grinding wheel acts as the tool. Silicon carbide abrasive coated brass grinding wheel act as tool instead of copper bonded diamond wheel.

Fig 2.2 is the 3d model of abrasive coated brass grinding wheel. The silicon carbide abrasive ac as an insulation between tool and workpiece.

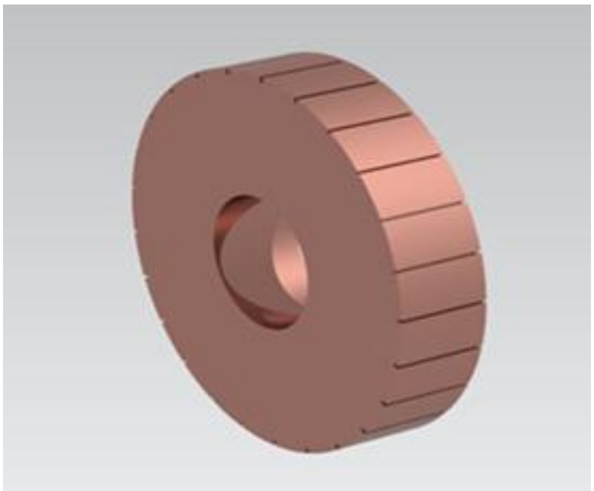

Fig. 2.2 3D Grinding Wheel Design

2.2 Dimensions of grinding wheel

Table. 2.1 Grinding Wheel Design

Metal	Brass
abrasive	Silicon carbide
Abrasive type	grit
Grit size	150
Outer diameter	65
Inner diameter	25
thickness	15

The above table 2.1 explain the full details of the silicon carbide coated brass abrasive grinding wheel. Here we are using abrasive coated brass grinding wheel instead of diamond wheel. The abrasive is grit type and the size of 150.the outer diameter of the abrasive coated brass grinding wheel is 65mm and inner diameter of the abrasive coated brass grinding wheel is 25mm, width of the grinding wheel is 15mm.in this abrasive coated grinding wheel silicon carbide act as a insulation between tool and workpiece and also it removes surface oxidation layer (ion dissolution process) of the material.

2.3 Machining Parameters

For electrochemical grinding various parameters are there to control the machining MRR as major roll in high strength materials MRR as well as surface roughness also, here in this project take Three machining parameters, electrolyte concentration, voltage and electrolyte flow rate as shown in Table 2.2.

Table 2.2 Machining parameters low & high levels

Process parameters	Units	Levels	
		Low (-1)	High (1)
Voltage (V)	Volts	10	20
Concentration (C)	g^{-1} lits	75	125
Flow rate (U)	Lit/min	2	4

In this process there are three level full factorial designs is used by RSM process in Minitab. The various process parameters are involved in electrochemical grinding process. Especially the supply voltage, concentration and flow rate are more effective parameters to improve the MRR in ECG process. The feed rate and the wheel speed are constantly fixed in my project process. Then the concentration, supply voltage and electrolyte flow rate are three factors should be experimented in two levels. The low and high of two levels are involved in this process. Totally 20 experiments are conducted. The difference between the factors levels of 25, 5, 1 for concentration, supply voltage and flow rate respectively.

2.4 Material Removal Rate

Material removal rate is the main output in this process, in electrochemical grinding produce better removal rate compare than other non-traditional machining process, Material removal rate (MRR) is express its ratio between before machining weight of workpiece material and after machining weight of the workpiece material by time.

$$\mathbf{MRR = \frac{BMW-AMW}{MT}}$$

- MRR = Material Removal Rate (G/Min)
- BMW= Before Machining Weight (G/Min)
- AMW = After Machining Weight (G/Min)
- MT = Machining Time (Min)

. he response value of the process is the material removal rate. First to calculate the difference between the weight of the material before and after machining. Then the difference value is divided by the machining time.

2.5 Design of Experiments

Design of experiments is a optimization process ,here various optimization process are available in DOE ,we are using Minitab software for this optimization process, The experiment was planned using a three level full factorial by RSM.

The electrochemical grinding experiment conducted by using RSM optimization methodology by three level, here totally 20 experiments are conducted at low (−1) and high (1) level.

2.6 Conduct of Experiments

Monel 400 alloys was machined using silicon carbide coating brass electrochemical grinding wheel of diameter 65 mm on ECG machine.

The positive current is (Anode) is connected to the workpiece (Monel 400) and the negative current is connected to the tool (silicon carbide coating brass electrochemical grinding wheel). The 90%-98% of the work (material removal) is done by the chemical dissolution process or ion dissolution process. Then remaining 3%-5% of the work is done by the mechanical abrasive grinding process by the silicon carbide abrasive coating, this coating act as a insulation between tool and workpiece. Table 2.3 shows the RSM optimization three level parameters for this electrochemical grinding and the output taken most by material removal rate.

Table 2.3 Machining Conditions

Ex. No	Voltage Volts	Concentration g^{-1} lits	Flow rate Lit/min	MRR g/min
1	15	100	2	0.187
2	15	100	3	0.198
3	15	100	3	0.206
4	15	100	3	0.211
5	10	125	2	0.285
6	15	100	3	0.215
7	10	100	3	0.192
8	10	125	4	0.279
9	20	75	2	0.158
10	10	75	4	0.121
11	20	125	4	0.369
12	15	100	4	0.259
13	15	100	3	0.223
14	15	100	3	0.216
15	15	125	3	0.298
16	20	75	4	0.176
17	15	75	3	0.139
18	10	75	2	0.096
19	20	125	2	0.276
20	20	100	3	0.234

The Table 2.3 shows the two full factorial design of the experimentation. This process the 20 experiments are conducted. Then the process the concentration, voltage and flow rate are setting the random wise to done the experimentation. This are the inputs should be given the respected MRR values.

III. RESULT

After the completion of 20 experiments in various parameter's we have the output result, in this process material removal rate is a major parameters and we are going to plot this values in graph, this graph clearly view how the material removal rate is change or improve based on the current voltage, electrolyte concentration and electrolyte flow rate

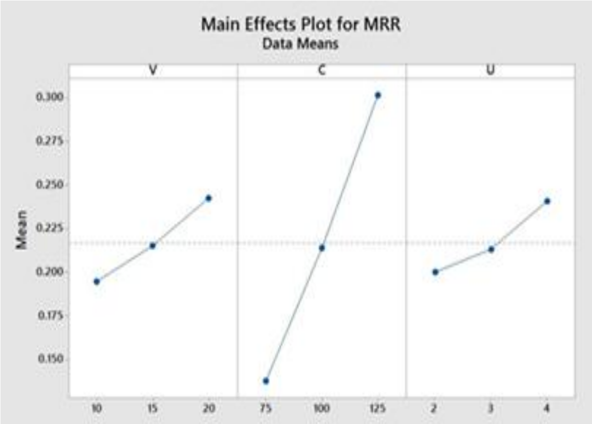

Fig. 3.1 Main Effect Plot For MRR

In this graph the voltage and electrolyte concentration and electrolyte flowrate and material removal rate are plot in the graph, while the voltage will increase at the same time MRR also increase depends upon the voltage ,when the electrolyte concentration increase from start material removal rate also increase based on electrolyte concentration at the same time electrolyte concentration do a good impact in material removal rate due to its ion dissolution process, while concentration of electrolyte increase chemical action also high so material removal rate also increase. Electrolyte flow rate also do a simple role in material removal rate, while the flow rate improve material removal rate also increase. The main effect plot for the material removal rate (MRR in g min^{-1}) with concentration, voltage and wheel speed is shown in fig 3.1. In this plot the MRR is more effective in the concentration and voltage. Then the flow rate should be given the small amount of improvements.

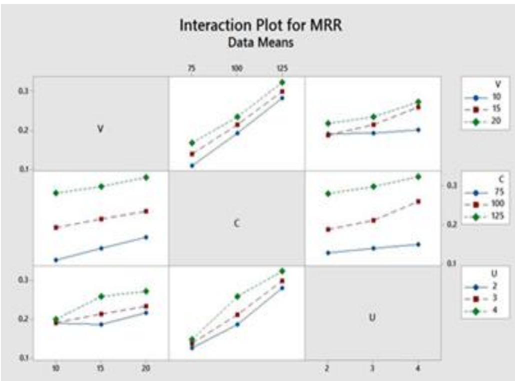

Fig. 3.2 interaction plot for MRR

The Interactive applied voltage, electrolyte concentration and electrolyte flow rate on MRR (g/min) is shown in Fig 3.2. The MRR should be increased in the interaction is shown in above.

Then the other interaction also given the better improvement of the material removal rate is shown in the Fig 3.2.This are the plots are obtained by the MINI Tab application. To fix the MRR is the response value and the concentration and voltage are interaction to get the best result. The MRR is increase based on the applied voltage, electrolyte concentration and electrolyte flow rate but the voltage and electrolyte concentration plays a major role in material removal rate as shown in Fig 3.2.

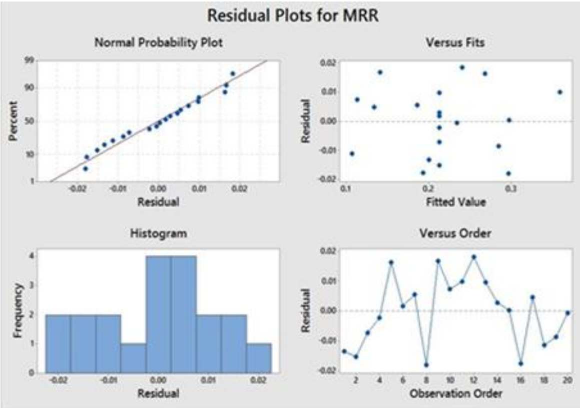

Fig. 3.3 Residual plot for MRR

The residual plot for MRR in g min^{-1} is shown in fig 3.3. The normality probability plot also shown. The dots in the plot is placed in the nonlinear line is shown. So this process is effective the histogram of the residual plot also given. Then this also given the best improvement of the result. So this process is more effective. The versus fits and fitted values of the residual plot is shown. This plot the dots are evenly separated up and down. So this process is effective. The versus order and fitted observation order of the residual plot is shown. This plot the dots are evenly separated up and down. So this process is effective. So the over result from the residual plot are given the best result and our process of the experiments are more effective.

IV. CONCLUSION

The present electrochemical grinding is conducted to Monel 400 alloy with silicon carbide abrasive coated Brass electrochemical grinding wheel. The effective MRR are studied with various setting of voltage, concentration and flow rate. The most effective parameters for better removal rate is applied voltage and electrolyte concentration. Furthermore, the flow rate has very little effect. The voltage 20 ,electrolyte concentration 125 g/lit and electrolyte 4 lit/min combinational parameters are produced better material removal rate compare than other process With silicon carbide abrasive coated Brass electrochemical grinding wheel is more effective performance in machining Monel 400 alloy.

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AUTHORS PROFILE

Mr.P.Mohan ME is presently working as an assistant professor in the Department of mechanical engineering, M.A.M College of engineering, Trichy. He achieved gold medal in his master degree (ME-CAD) in GCE-Salem and published two papers in international journals, he is also a life member of international association of Engineers (IAENG).