Experimental Investigation of Generating U Shaped Cavity on AISI D2 Tool Steel using ECM

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***Abstract:-*Electro-chemical machining (ECM) process uses replica image of tool on the work surface with the chemical reaction through machining. ECM is one of the best methods for making U shaped cavity on worksurface, that are difficulty to other machining process. The aim present work is an attempt to making U shaped cavity using Rotary U-shaped copper electrode (tubular) in electrochemical machining. Material removal of making blind cavity which significantly reduces the machining cost as well as the operating and tooling cost in process of machining in ECM. AISI D2 tool steel material has been selected for making blind cavity with help of ECM. Machining parameters selected for this study are tool feed rate, diameter of electrode and voltage, with use of Taguchi design of experiment techniques.**

***Key word* - AISI D2 tool steel, Electro Chemical Machining (ECM), Material Removal Rate, Taguchi design, U-shaped cavity, tubular electrode.**

I. INTRODUCTION

ECM is the one of best method for machining for hard material and making difficult shape by using chemical reaction with anodic dissolution in an electrolytic cell. Darning machining worksurface is to be set as positive and tool is set be negative in the following electrolyte. **Kozak et al. [1]** has reported the difficult type of shape making with state polarity is used by the micro-features of the cathode-tool electrode under given machining conditions. **Huaiqian et al. [2]**is used to micromachining technology under different machining condition and making complicated shaped, with help of pure water as electrolyte. **Hee Jo et al. [3]** has also reported for micromachining techniques for the machining of side wall of a micro hole. **Rahman et al. [4]** discusses about the growing demand for industrial products not only with increased number of functions but also of reduced dimensions.

Tiwari et al. [5] has been applied a mathematical model of material removal rate and surface finish as output by using regression equation of EN-19 tool steel material and analyzed variance of the responses through this equationThe electrochemical machining is also used for Machining deep holes, micro-grooves, and micro-channels on the nonconductive materials **[6]. Park et al. [7]**used as micro electrochemical machining process forultra-short pulses in machining parameters. **Bhattacharyya et al. [8]**has been used for making complicated micro tool type of workpiece making, with the help of electrochemical micromachining. This type of work generally used in precision manufacturing industries, micro tool making industries. Parametric optimization has been analyzed by using electrochemical machining in very complicated shape making for various researchers **[9-12].**

According to the previous research work they find that difficulty face during machining of conventional machining for making difficulty shape of worksurface. The aim to the present work using U-shaped blind hole using tubular copperelectrode in AISI D2 tool steel.The selected controlparameters are tool feed rate that are very with four different ranges, diameter of electrode and voltage both are vary with two ranges total eight experiment have been conducted using Taguchi design of experiment.

II. EXPERIMENTAL SETUP AND TOOL DESIGN

This experiment has been conducted on Electrochemical Machining Model 50 HZ (0-300A DC) Range of voltage in this machine is 0-25V, with 80%. efficiency at partial and full load condition. The main component of this machine is machining cell, control panel and Electrolyte Circulation.

2.1 Selection of tool and workpiece

In this experiment using U-Shaped copper tool electrode with 60 mm diameter, flexible pipes, and plastic spur gear. The holderthat is supporting the plastic spur gear for the motion of rotation of tool with the help of belt drive.

The experiment was performed in copper U shaped electrode with internal hole that are shown in Fig. 1 (length of 75mm with two different diameters 4mm and 6mm). Tool is set to be negative terminal such as cathode for better machining. And this copper tool bend with according to the design of U shaped, and 2mm hole provided with the help of drill bit for electrolyte flowing to the worksurface.

Fig. 1 U-shaped Copper Tube

With the help of U-shaped tool create a blind hole in the workpiece of AISI D2 steel. The size of the work piece is 100 mm in diameter and 60 mm in thickness (Fig .2). For every sample piece two experiment are performed with depth of 25 mm and length is 35 mm. Material removal rate to be calculated with the help of weight loss method.

Fig.2 Work piece after machining for run 1 and 2

III. EXPERIMENTAL PROCEDURE

Experiment are performed in two different steps

3.1 STEP 1

Before performing the experiment calculate the weight of work piece and after conducting the first set of experiment calculate different of weight and finding weight loss of doing experiment. During machining of step 1 of work piece is kept in horizontal position. U shaped electrode in vertical position cutting in this steps tool is not rotates up to 25 mm depth in central position. After completed the first step then started second step.

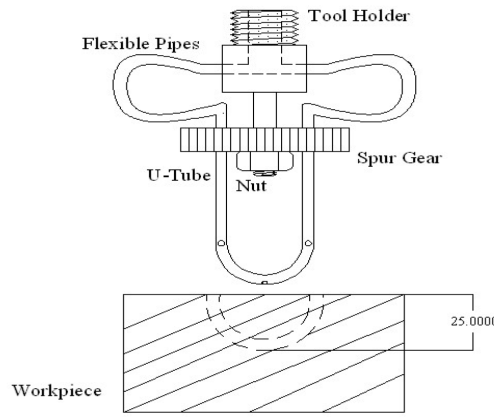

Fig. 3Before Machining (Step1)

3.2 STEP 2

Now in step 2 the experiment is done in rotary movement of tool in this steps feed is set to be zero and other parameters are same as pervious step 1. The rotation of tool starts from 25mm depth where the rotation speed of the tool is 0.01rpm to 0.1rpm. The tool is rotated through 180° due to this the cavity is formed on the workpiece. Then the final weight of the workpiece is noted.

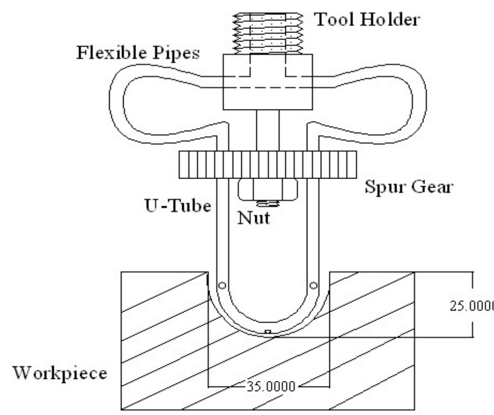

Fig.4after Machining (Step 2)

Table-1 Design of Experimentation and their calculated value

Run	Feed (mm/min)	Voltage (V)	Tool Dia (mm)	MRR (mm^3/min)	OC-dia (mm)	OC-depth (mm)
1	0.1	10	4	0.05994	4.135	5.592
2	0.1	15	6	0.09258	4.418	5.378
3	0.2	10	4	0.05856	3.457	7.715
4	0.2	15	6	0.09596	4.049	7.553
5	0.3	10	4	0.07748	1.569	8.182
6	0.3	15	6	0.17081	2.044	7.799
7	0.4	10	4	0.10401	0.602	9.611
8	0.4	15	6	0.18874	0.59	9.418

Effect on machining parameters for analysis of MRR

When machining of electrochemical process effect of material removal rate is depending upon the following machining parameters such as electrolyte concentration, feed rate of electrode, inter electrode gap and electrolyte flow rate, voltage and diameter of tool. The effect of machining parameters on material removal rate with three control parameters are presented in Fig 4. According to the main effect plot of MRR slightly increases at the range of 0.1 feed rate after that feed rate have huge increases on the analysis of MRR, because more material eroded for work surface. MRR is directly proportional to the voltage and minor effect on change in diameter to tool. This is also confirmed by ANOVA of MRR that is showing in Table 2.

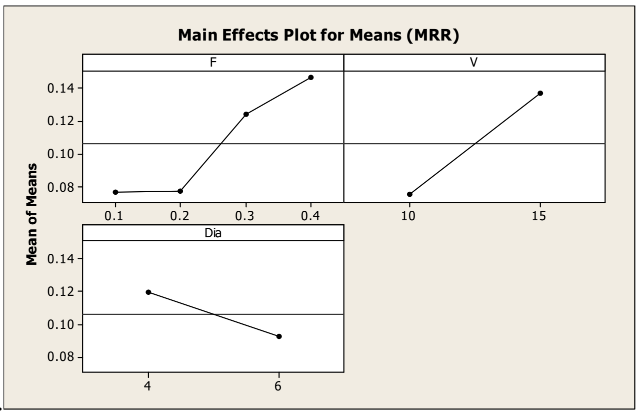

Fig. 5 Main effects of machining parameters on MRR (data means)

Table-2 Analysis of Variance for Means of MRR

Source	DF	Seq SS	Adj MS	F	P
Feed	3	0.007340	0.002447	202.16	0.005
Voltage	1	0.007695	0.007695	635.85	0.002
Dia	1	0.001458	0.001458	120.51	0.008
Error	2	0.000024	0.000012		
Total	7	0.016517			

Effect on machining parameters for analysis of overcut-diameter (OC-diameter)

The effect of control parameters on analysis of overcut diameter the feed rate is most significant parameters followed by voltage and then diameters of tool. According to the main effect plot of overcut diameter, feed rate is increase up to 0.2 mm/min OC-diameter is increases after that value of OC-diameter is reduced simultaneously. Overcut diameter is directly proportional to the voltage in other word OC-diameter is increases with increase in voltage. OC-diameter also increases with higher electrode diameter.

This is also concluded the analysis of variance of overcut diameter that are presented in Table 3.

Table-3 Analysis of Variance for Means of Overcut-diameter

Source	DF	Seq SS	Adj MS	F	P
Feed	3	17.5423	5.84743	143.95	0.007
Voltage	1	0.2265	0.22653	5.58	0.142
Dia.	1	0.0205	0.02046	0.50	0.551
Error	2	0.0812	0.04062		
Total	7	17.8705			

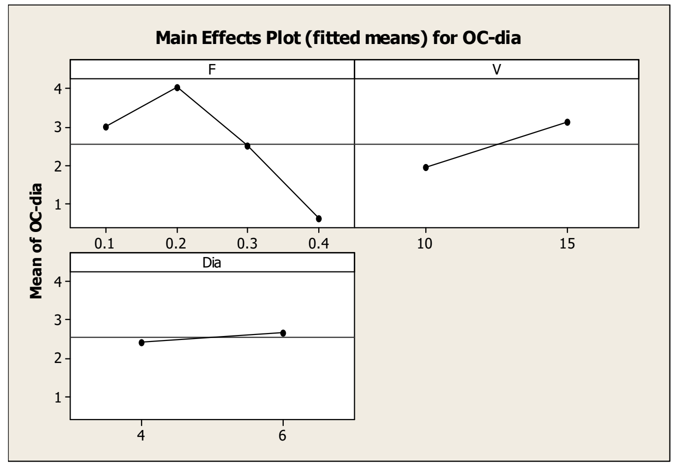

Fig. 6 Main effects of machining parameters on Overcut diameter (data means)

Effect on machining parameters for analysis of overcut- depth (OC-depth)

The analysis of overcut depth measurementdifferent input parametersis significantly affected. Feed rate value are directly proportional to the overcut depth in other word when increase in value of feed rate during experiment OC-depth is also increase, that is clearly indicate in Fig. 7 main effects plot for OC -depth. When increase in voltage overcut-depth decreases. According to the analysis of variances (Table 4) of overcut depth electrode diameter has no significant effect on it.

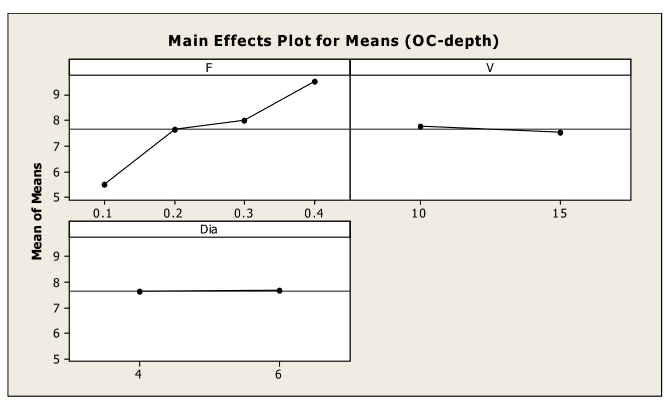

Fig. 7 Main effects of machining parameters on Overcut depth (data means)

Table-4 Analysis of Variance for Means of overcut-depth

Source	DF	Seq SS	Adj MS	F	P
Feed	3	16.5593	5.51976	1137.98	0.001
Voltage	1	0.1133	0.11329	23.36	0.040
Dia.	1	0.0050	0.00500	1.03	0.417
Error	2	0.0097	0.00485		
Total	7	16.6873			

IV. CONCLUSIONS

The current work is to evaluate the U-shaped cavity in AISI D2 tool steel using Rotary U-shaped copper electrode (tubular) in electrochemical machining. Total eight experiment to be performed using Taguchi design of experiment techniques. By making this cavity measurement of various responses such as Material removal rate, overcut diameter and overcut depth, with selected machining parameters like tool feed, voltage and diameter of tool. The MRR increases with increase in feed and voltage. The overcuts with diameter and depth of cavity are influenced by feed and voltage. All these over cuts reduce with increase in feed and diameter of electrode.

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