ISSN No. 2455-5800
Journal of Scientific Research in Allied Sciences

Review Article

REVIEW ON ELECTROCHEMICAL MACHINING OPERATION FOR OPTIMIZATION PARAMETER

Sunil Swami Dubey, Ashish Kumar Khandelwal

Mechanical Engineering Department
Chouksey Engineering College, Bilaspur

Article history:
Submitted on: July 2017
Accepted on: July2017
Email: info@jusres.com

ABSTRACT—

This paper deal with one of nontraditional machining operation known as Electrochemical Machine experiment highlights features of the development of a comprehensive mathematical model for correlating the interactive and higher order influences of various machining parameters on the dominant machining criteria i.e. the material removal rate (MRR), surface roughness (SR) and overcut (OC) phenomenon through Response Surface Method (RSM) method using the pertinent experimental data as obtained by experiment. The present work has been done to find the material removal rate, surface roughness and overcut by electrochemical dissolution of an anodically polarized work piece (AISI304 stainless steel) with a copper electrode of hexagonal cross section. The factors also affect the performance are discussed and elaborated.

KEYWORDS: Electrochemical Machining (ECM), Material removal rate, Surface roughness, Overcut, Response Surface Methodology

INTRODUCTION

ECM is a nontraditional machining process which is used to machine difficult to machine materials such as alloy steel, Ti alloys, super alloys and stainless steel etc. ECM is characterized as reversed electroplating process. In the year 1983, Faraday established the laws of electrolysis (electroplating). This is the basis for this process which is very popular not only in the industries, but outside these industries also for some other purposes like for electroplating of different materials. ECM is a controlled anodic dissolution process in which a very high current is passed between the tool which is cathode and work piece which is made anode, through a conductive fluid which is also called electrolyte. It is a non contact process in which the cavity obtained is the replica of the tool shape.

In ECM work piece is dipped in a working fluid also called the electrolyte and electrolyte continuously flows through the inter electrode gap between the anode and the cathode. When power supply is switched on, removal of material takes place from work and ions are washed away by flowing electrolyte solution. Metal hydroxide ions are formed by the ions which by centrifugal separation are removed from the conductive electrolyte solution. ECM process is found advantageous particularly for high strength super alloys. ECM is an important process for semiconductor devices and the thin metallic films because of a basic requirement of semiconductor industry is the machining of components of critical shape and high strength alloys. This process is also used for shaping and finishing operation in aerospace and electronic industries for different parts of the opening.

LITERATURE REVIEW

B. Bhattacharyya et.al [1999] has reported that the electrochemical micro machining as it offers numerous advantages, seems to be promising as a future micro-machining method. A suitable micro tool vibration framework is created, which comprises of micro tool vibrating unit, micro tool vibrating unit, etc. The framework developed was utilized effectively to control MRR and accuracy of machining to meet small scale machining prerequisites. Micro-holes were created on thin copper work piece by EMM using micro tool of stainless-steel. Trials have been completed out to estimate the process parameters for example electrolyte concentration, amplitude and micro-tool vibration frequency for creating micro-hole with high exactness and calculable measure of MRR.[4].

Joao Cirilo da Silva Neto et.al [2006] demonstrates an investigation of the intervening parameters in ECM. The parameters studied in this paper are material removal rate (MRR), over-cut and hardness. Four parameters were changed amid the experiments: flow rate of electrolyte, feed rate, voltage and electrolyte. Two solutions of electrolyte were used: sodium nitrate ($NaNO_3$) and sodium chloride (NaCl). The results demonstrate that feed rate was the principal parameter influencing MRR. [5]

S K Mukherjee et.al [2001] talks about role of NaCl in process of carrying current in electrochemical machining of iron work piece. Over-voltage-computed regarding equilibrium gap and penetration rate, demonstrates that only a small range of penetration rate and equilibrium gap are allowable.[6]

K. P. Rajurkar et.al [1993] examined the important advantages of the ECM procedure, for example, high MRR, damage-free and smooth machined surface, are regularly counter balanced by the poor control of dimension. This paper based on the fundamental ECM dynamics presents a model of controlling ECM that accounts for the dynamic nature of the ECM process. The approach of state space is used to change it into the control model appropriate to an ECM control system based on a digital computer.[7]

Yuming Zhou et.al [1995] discussed about the prior techniques for tool design in ECM. In this paper, actually create and test another way to deal with this issue which controls these troubles by utilizing a FEM inside an optimization formulation.[8]

K.P. Rajurkar et.al [2002] had demonstrated that ECM method now progressively used in other commercial enterprises where components with hard-to-cut materials and critical shape are needed. The most recent developments are examined, and primary issues in ECM improvement and related exploration have been raised. Improvements in designing of tool, micro-shaping, finishing, pulse current, numerically controlled and hybrid processes.[9]

H. Hocheng et.al [2003] reported about the methods to produce a hole of hundreds of micrometers on the surface of metal. It additionally talks about the effect of variables such as molar concentration and time of electrolysis, voltage and electrode gap upon the measure of MRR and dia of hole made. Results show the MRR increases with increasing molar concentration of electrolyte, electrical voltage.[10]

Anjali V. Kulkarni et.al [2009] talked about the present patterns & methods utilized for micro fabrication of parts. This paper tries to make a reasonable, fast micro fabrication & cost effective method. Focused on utilization of ECS for layered manufacturing in micron.[11]

A.K.M. De Silva et.al [2012] talked about the Electro
chemical machining (ECM), which is used to attain surface finish 0.03ms µRa and accuracy better than 5 µm by utilizing pulsed power of comparatively short durations (1 - 10 µs) and small IEG (10 – 50 µm). The small IEG make the process significantly critical than ordinary ECM.[12]

Mohan Sen et. al [2005] examined that the Electro chemical machining methods produce for drilling micro parts and macro-holes of smooth surface and reasonably satisfactory taper in various industrial applications especially in aerospace and computer industry.[13]

PROBLEM IDENTIFICATION

Out of the Non conventional machining method ECM required Highest Specific cutting energy. So as the material is having Poor machine ability index like stainless steel required lot of amount of energy for performing the number of task.

In order to perform the work satisfactorily and overcome above problems we required to optimize the process parameter such that the productivity increases and the Specific cutting energy should be as low as possible.

By considering all the above factors the Objective of the work has been decided that present work is to optimize the material removal rate (MRR), surface roughness (Ra) and overcut (OC) for the stainless steel (AISI304).

OBJECTIVE OF PRESENT WORK

The objective of present work is to optimize the material removal rate (MRR), surface roughness (Ra) and overcut (OC) for the stainless steel (AISI304) with a Cu electrode. In my work flow rate of electrolyte, the current across the work electrodes and electrolyte conductivity is kept constant.

- Optimize the material removal rate (MRR), surface roughness (Ra) and overcut (OC) for the stainless steel (AISI304) with a Cu electrode.
- Perform response surface methodology for obtaining required parameter.

MATERIAL AND METHOD

Experimental set up

The experiments the have been carried out on ECM set up supplied by Metatech-Industry, Pune which is having Supply of - 415 v +/- 10%, 3 phase AC, 50 HZ. And consist of three major sub systems which are being discussed in this chapter.

Tool design

Generally non reacting material such as Copper is used as tool in ECM. Cathode material taken in this experiment is made up of copper rod of length 40 mm with hexagonal cross section at one end having length of each side equal to 10 mm, a through gap is made at the middle by a 3 mm boring tool made up of fast steel.

Work piece material: AISI 304 Stainless Steel

For this experimental investigation we have chosen AISI 304 Stainless steel as work piece. Work piece is having dimension of 100 X 60 mm and 5 mm in thickness.

Making of Brine Solution or Electrolyte

Electrolyte is prepared by addition of common salt with water while maintaining the conductivity of water. So we have to take salt solution. In order to maintain the material removal rate correctly we have to maintain the conductivity throughout the end of the experiment. For this experiment we have taken 100 gm of salt,125 gm of salt and 150 gm of salt sample in 1000 mL of water in room temperature.

Response Surface Methodology (RSM)

Response Surface Methodology (RSM) is collection of mathematical and statistical methods for building experimental model and analysis of problems. By careful design of experiments, the objective is to optimize a response (output variable) which is influenced by several independent variables (input variables) with a goal to find the correlation between the response and the variables.

A Central Composite Design (CCD) predicts the performance characteristic at high degree of accuracy during experimentation. Therefore, RSM using CCD with three variables yield a total of 20 runs in three blocks, where the cardinal points used are; 8 cube points, 6 axial points and 6 centre points [Minitab16, 2011]. Electrolyte concentration, voltage and feed rate were the three experimental factors capable of influencing the process responses, namely, MRR, SR and OC. Hence, these factors were considered for exploration.

Procedure of the experiment

Before starting the experiment measure the initial weight of the work piece using a precision electronic balance (least count 0.001 g) to calculate the MRR. After setting all the parameters in the control panel (like feed rate, voltage, current and time) and setting the work piece in the chamber, machining was started by using a copper electrode. The time of machining of the work piece at certain feed rate and voltage is being noted down. The values of surface roughness are measured by means of a portable type profilometer, Talysurf (Model: Surtronic 3+, Taylor Hobson). After measurement it is calculated by arithmetic mean of two data as the absolute value**.** Overcut is calculated after observation of machined surface under Tool makers microscope.

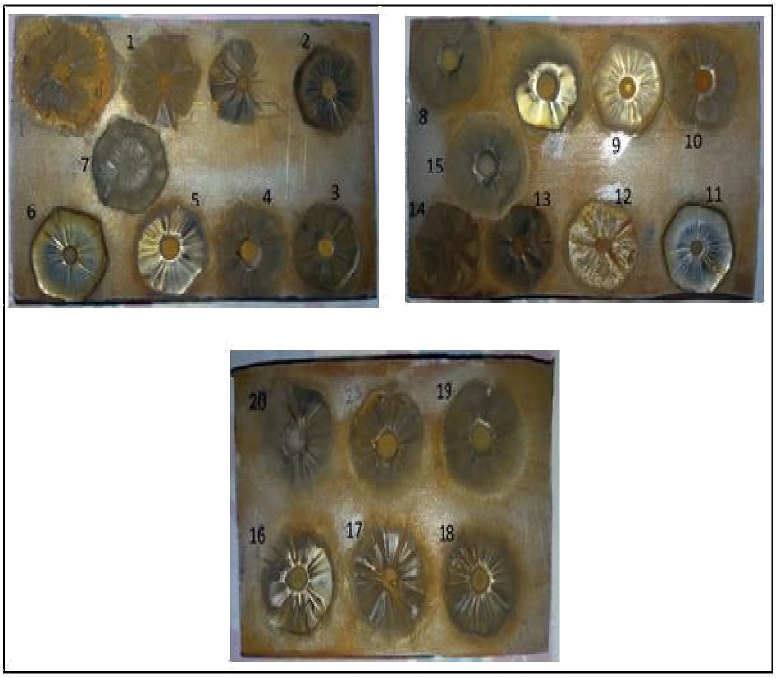

Figure 1 : Work piece after machining.

RESULT AND DISCUSSION

Effect on Material removal rate: The machine ability of ECM depends on the electrolyte concentration, feed rate and voltage. The influence of various machining parameters on MRR (means) are shown in figure 2. The MRR gradually decreases with increase in electrolyte concentration and then decreases. But MRR decreases with increases in feed rate first and then increases.

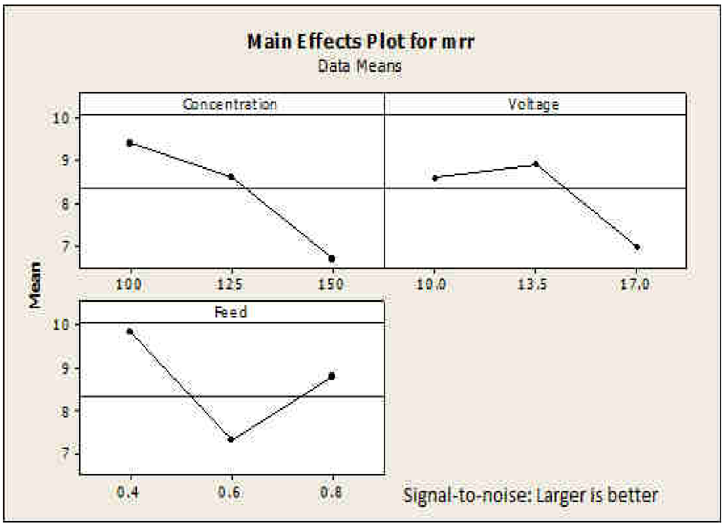

Figure 2: Main effects of machining parameters on MRR (data means)

Effect on Surface Roughness (SR): The influence of various machining parameters on SR (means) is shown in fig. 3. The SR slightly increases with increase in concentration and then decreases. SR increases with increase in voltage. But at first SR decreases with increases in feed and then increases.

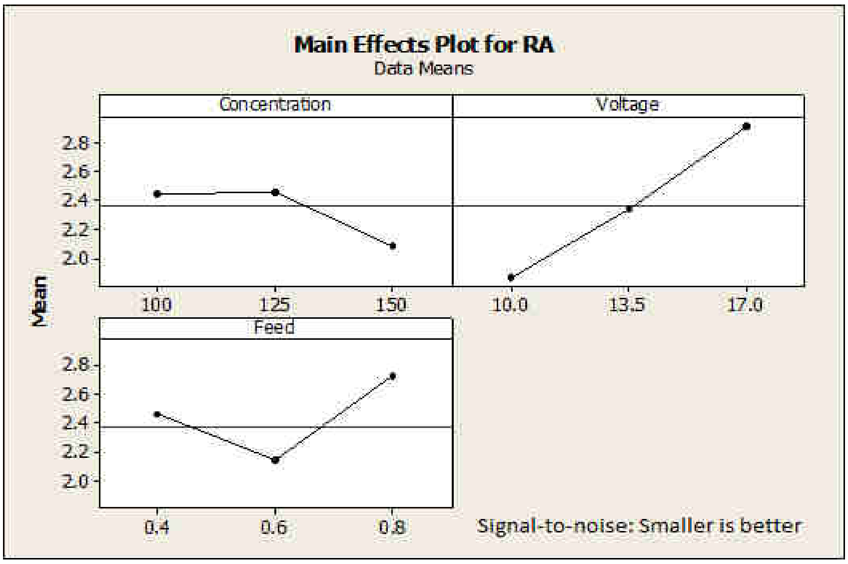

Figure 3 : Main effects of machining parameters on SR (data means)

Effect on Overcut (OC): The influence of various machining parameters on overcut (means) are shown in figure 4. The overcut increases with increase in electrolyte concentration firstly and then decreases. Overcut increases with increase in voltage in the range and then decreases. Overcut increases with increase in feed rate first and then decreases.

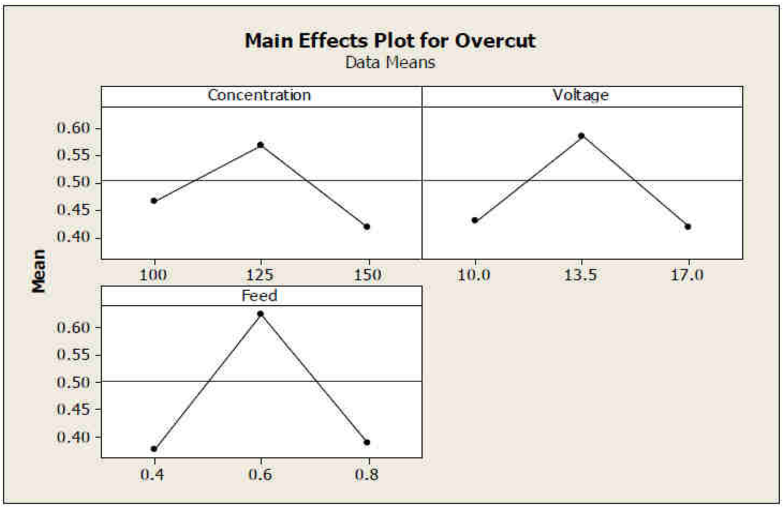

Figure 4 : Main effects of machining parameters on Overcut (data means)

CONCLUSION

The experiment was conducted under various machining parameters setting of voltage (V), feed (F) and electrolyte concentration(C). Experiments were conducted using RSM design which was performed by Minitab software and results were analyzed and these responses were partially validated experimentally

1. MRR gradually decreases with increase in electrolyte concentration. MRR increases with increase in voltage in the range of 10 to 13.5 and then decreases. But MRR decreases with increase in feed rate in the range 0.4 to 0.6 and then increases. The optimum condition for maximum MRR is electrolyte concentration 100 gm/lit, voltage 13.5 volts and feed rate 0.6 mm/rate.
2. The SR slightly increases with increase in concentration in the range 100 to 125 and then decreases. But SR decreases with increases in feed in the range 0.4 to 0.6 and then increases. The optimum condition for minimum surface roughness is electrolyte concentration 125 gm/lit, voltage 10 volts and feed 0.6mm/min.
3. OC increases with increase in electrolyte concentration in the range 100 to 125 and then decreases. Overcut increases with increase in voltage in the range of 10 to 13.5 and then decreases. Overcut increases with increase in feed rate in the range 0.4 to 0.6 and then decreases. The optimum condition for minimum overcut is electrolyte concentration 150

gm/lit, voltage 17volts and feed rate 0.4 mm/min.

REFRENCES

1) NPTEL lecture modules.
2) Investigation of process parameters in ECM lecture module.
3) Module of Estimation of MRR in Electrochemical Machining.
4) B. Bhattacharyya, S.K. Sorkhel Investigation for controlled electrochemical machining through response surface methodology-based approach Journal of Materials Processing Technology 86 (1999) 200–207.
5) Joao Cirilo da Silva Neto, Evaldo Malaquias da Silva , Marcio Bacci da Silva Intervening variables in electrochemical machining Journal of Materials Processing Technology 179 (2006) 92–96.
6) S K Mukherjee, S Kumar, and P K Srivastava Effect of electrolyte on the current- carrying process in electrochemical machining Proc. I Mech E Vol. 221 Part C: J. Mechanical Engineering Science (2001).
7) K. P. Rajurkar, B. Wei, .c. L. Schnacker Monitoring and Control of Electrochemical Machining (ECM)Journal of Engineering for Industry May 1993, Vol. 115/217.
8) Yuming Zhou and Jeffrey J. Derby The cathode design problem in Chemical Engineering Science, Vol. 50, No. 17, pp. 2679 2689, (1995).
9) K.P. Rajurkar, D.Zhu, J.A. Mc Geough, J. Kozak, A. De Silva New Developments in Electro-Chemical Machining research paper (2002).
10) H. Hocheng, Y.H. Sun, S.C. Lin, P.S. Kao A material removal analysis of electrochemical machining using flat-end cathode Journal of Materials Processing Technology 140 (2003) 264– 268.
11) Anjali V. Kulkarni and V. K. Jain Micro fabrication using Electrochemical Spark Mechanical Engineering Department Indian Institute of Technology, Kanpur-208016 (2009).
12) A. K. M. De Silva, H. S. J. Altena, J. A. McGeough Precision ECM by Process Characteristic Modeling Journals of precession engineering (2012).
13) Mohan Sen., H.S. Shan A review of electrochemical macro- to micro-hole drilling processes International Journal of Machine Tools & Manufacture 45 (2005)137-152.