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Original Research Article

EXPERIMENTAL EXAMINATION ON ELECTROCHEMICAL MACHINING PARAMETER FOR OPTIMIZATION

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Abstract: This paper deals with Electrochemical machining method 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. Experiments were conducted to analyze the influence of machining parameters such as feed rate, voltage and electrolyte concentration. Analysis of variance (ANOVA) is employed to indicate the level of significance of machining parameters. It is observed that concentration is the most significant factor for response of material removal rate and in case of surface roughness voltage is the most significant factor. For response of overcut, the voltage is most significant factor. The factors also affect the performance are discussed and elaborated.

Key Words: Electrochemical Machining (ECM), Material removal rate, Surface roughness, Overcut, Analysis of variance (ANOVA).

Introduction: One of the most commonly used non-traditional machining process named as Electrochemical Machining which is used to machine difficult-to-machine materials such as stainless steel etc along with used for making complex contour shape on work piece material. The basic working principle is based on “Faraday law of electrolysis” and mechanism of machining is “ion displacement” due to which the material removal takes place atom by atom by the process of electrolysis.

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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.[1]

Literature Review: ***S.K. Mukherjee et.al [2008]*** characterized that MRR of aluminum work piece has been calculated by ECM utilizing NaCl electrolyte at various current densities, also compared with the theoretical values. It is also concluded that resistance offered by electrolyte arrangement decreases sharply with expanding current densities, and simultaneously the over-voltage of framework first increases and afterwords achieves a saturation value with expanding current densities.[2]

V.K. Jain et.al [2008] has reported that electrochemical spark machining method has been effectively used for cutting quartz utilizing a controlled feed and a wedge edged tool. In ECSMWRP, deep cavity on the anode (as a tool) and work piece interface is formed in view of substance response. The cutting is possible regardless of the possibility that we make small size auxiliary electrode.[3]

K.L. Bhondwe et.al [2006] in this paper endeavors to build up a thermal model for calculating MRR in ECSM process. To begin with, temperature profile inside zone of influence of single spark is acquired with the utilization of FEM. The nodal temperature plays an essential role in finding MRR. The created thermal model based on FEM is discovered to be in the range of accuracy with the trial results. The increment in MRR increases with increase in electrolyte concentration.[4]

R V Rao et.al [2002] talked about the estimations of critical process parameters of ECM methods such as feed rate, flow velocity of electrolyte, and voltage play a important role in improving the measures of process performance. These incorporate dimensional accuracy,
MRR, machining cost and tool life.[5]

Jerzy Kozak et.al [2004] investigated about the hypothetical and trial examinations of the relationship between the characteristic shape measurements imported upon the work piece surface by the micro-features of the tool electrode under given machining conditions. This work incorporated the investigation of electrochemical insulating groove features, copying of grooves and slots mini-holes.[6]

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.[7]

J.A. Westley et.al [2004] examined about the steady electrolyte flow. This paper tries to recognize the elements, for example, insulation prerequisites that can identify with other parts of ECM. These perceptions would then be utilized while creating ECM electrodes. Work has been done in this paper by taking new cathodes for removing casting gate.[8]

Chunhua Sun et.al [2006] highlighted about the precise forecast of tool shape for ECM. It proposes a methodology utilizing FEM for designing tool in ECM. This process is able to draw 3-D freestyle surface tool from the scanned information of work piece.[9]

S. K. Mukherjee et.al [2005] described about the Material removal rate in ECM process by utilizing conductivity and over voltage of the electrolyte. It is found that over voltage plays an significant role than feed rate and IEG. MRR drops as over voltage increases and current efficiency decreases, which is directly related to the electrical conductivity of the electrolytic solution.[10]

Se Hyun Ahna et.al [2004] examined about the uncommon use of Electro-chemical machining in micro machining on the grounds that the electric field is not localized. In this work, to localize dissolution zone ultra short pulses with tens of nanosecond duration are used. The effects of pulse duration, voltage and pulse frequency on the localization distance were measured. 8 µm diameter high quality micro hole was drilled on workpiece of 304 stainless steel foil with 20 µm thickness.[11]

Problem Identification: In most of the turbine blades is made up of stainless steel which is having the Poor machine ability material so it is very difficult to machine such material by the conventional machining method. Along with such for the turbine blades it is required to produce complex concave contour shape which is having huge number of cavities on its surface for creating velocity and pressure compounding. This is only possible by the help of one of the non conventional machining that is Electrochemical machining.ECM required Highest Specific cutting 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.
- Work piece material is AISI 304 SS and the selected machining parameters for study are feed rate, voltage and electrolyte concentration.
- To indicate the level of significance of machining parameters Analysis of variance (ANOVA) is employed.

Material and Method

Experimental set up: The experiments the have been carried out on ECM set up supplied by Metatech-Industry, Pune This electro-mechanical assembly is a tough structure, connected with precision machined segments, servo mechanized vertical up / down motion of tool, an electrolyte dispensing course of action, illuminated machining chamber with transparent window, vice for job fixing, mechanism for lifting of job table and strong stand.

Total Area=259.8mm^2, Cross head stoke=150 mm,

Job holder=100mm.opening X 50mm.depth X 100mm.

Tool feed motor= DC servo Type

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.

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 an 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 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 increases in feed rate in the range 0.4 to 0.6 and then increases.

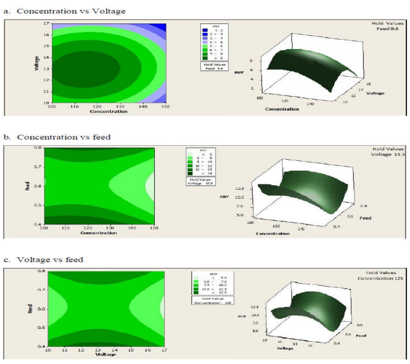

Figure 2 : Contour and surface plot for MRR

Effect on Surface Roughness (SR): The SR slightly increases with increase in concentration in the range 100 to 125 and then decreases. SR increases with increase in voltage. But SR decreases with increases in feed in the range 0.4 to 0.6 and then increases.

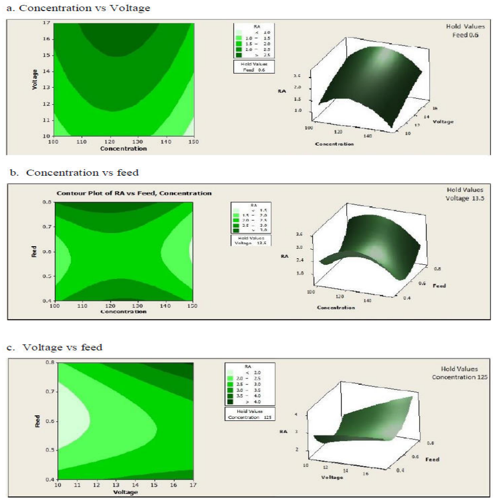

Figure 3 : Contour and surface plot for SR

Effect on Overcut (OC): The overcut 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.

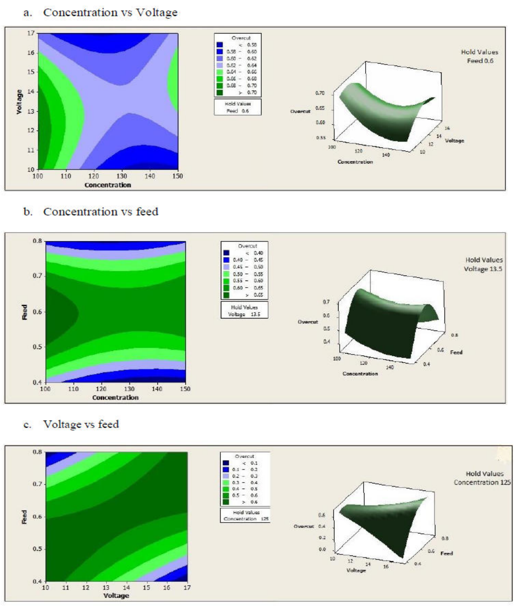

Figure 4 : Contour and surface plot for OC

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 Analysis of variance (ANOVA) is employed to indicate the level of significance of machining parameters and results were analyzed and these responses were partially validated experimentally

1. MRR increases with decrease in concentration. MRR initially increases and then decreases when voltage increases. MRR initially decreases and then increases when feed increases.
2. SR decreases with decrease in voltage. SR initially increases and then decreases when concentration increases. SR initially decreases and then increases when feed increases.
3. OC increases with decrease in concentration. OC increases when voltage increases. OC initially increases and then decreases when feed increases.

The optimum condition for maximum MRR, minimum SR and min OC is electrolyte concentration 100gm/lit, voltage 17 volts and feed 0.6 mm/min. Overall response for maximum MRR, minimum SR and OC was most influenced by feed rate, then voltage and then electrolyte concentration.

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