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ANALYTICAL STUDY OF PROCESS PARAMETERS IN ECM USING COPPER ELECTRODE

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ABSTRACT
Electrochemical machining (ECM) has established itself as one of the major alternatives to conventional methods for machining hard materials and complex contours without the residual stresses and tool wear. ECM has extensive application in automotive, petroleum, aerospace, textile, medical and electronic industries. Studies on Material Removal Rate (MRR) are of utmost importance in ECM, since it is one of the determining factors in the process decisions. So the aim of present work is to investigate the MRR, overcut diameter and overcut depth of AISI P20 work piece by using a rotating copper U-tube tool. Four parameters were chosen as process variables: Feed rate, Voltage, Electrolyte concentration and Tool diameter. The results of experiment show the material removal increase with increasing the feed, voltage and electrolyte concentration but decreases with increasing the tool diameter, and for both overcut diameter and overcut depth they increases with increasing feed ,voltage and electrode diameter but decreases with increasing electrolyte concentration. Grey relation grade (GRD) was also applied to identify the optimal parameter setting in the experiment.

I. INTRODUCTION
Electrochemical machining (ECM) was developed to machine difficult-to cut materials, and it is an anodic dissolution process based on the phenomenon of electrolysis, whose laws were established by Michael Faraday [1]. In ECM, electrolytes serve as conductors of electricity. The rate of machining does not depend on the hardness of the metal. ECM offers a number of advantages over other machining methods and also has several disadvantages:

Advantages: there is no tool wear; machining is done at low voltage compared to other processes with high metal removal rate; no burr formation; hard conductive materials can be machined into complicated profiles; work-piece structure suffer no thermal damages; suitable for mass production work and low labour requirements.

Disadvantages: a huge amount of energy is consumed that is approximately 100 times that required for the turning or drilling of steel; safety issues on removing and disposing of the explosive hydrogen gas generated during machining; not suited for nonconductive materials and difficulty in handling and containing the electrolyte.

ECM Machine Parameters

1. Servo System: The servo system controls the tool motion relative to the work piece to follow the desired path. It also controls the gap width within such a range that the discharge process can continue.
2. Electrolyte: The electrolyte is essential for the electrolytic process to work. The electrolyte has three main functions in ECM. These three functions are:
   a. It carries the current between the tool and the work-piece.
   b. It removes the products of machining from the cutting region.
   c. It dissipates heat produced in the operation
3. Tool Feed Rate: In ECM process gap about 0.01 to 0.07 mm is maintained between tool and work piece. For smaller gap, the electrical resistance between the tool and work is least and the current is maximum and accordingly maximum metal is removed.

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4. Material Removal Rate: It is a function of feed rate which dictates the current passed between the work and the tool. As the tool advances towards work, gap decreases and current increases which increases more metal at a rate corresponding to tool advance.
5. Tool Design: As no tool wear takes place, any good conductor is satisfactory as a tool material, but it must be designed strong enough to withstand the hydrostatic force, caused by electrolyte being forced at high speed through the gap between tool and work.
6. Pumps: Single or multi-stage centrifugal pumps are used on ECM equipment. A minimum flow rate 15 litres/min per 1000 A. Electrolyzing current is generally required. A pressure of 5-30 kg/cm^2 meets most of the requirements of ECM application
7. Filtration and Storage Tank: The filtration of electrolyte is essential to prevent small particles of grit, metal, plastics and products of machining from entering the machining gap and causing interference in the process, for these a 5 micron polypropylene pleated filter cartridge have been used with stainless steel housing arrangement.
8. Valves and Piping: The piping and control valves which supply electrolyte to the ECM tooling, must not introduce foreign matter into the electrolyte. Stainless steel is the most suitable material for valves and piping .

II. LITERATURE REVIEW

D. Zhu et al. [1] proposes a finite element approach to accurately determine the electrode profiles. The proposed method does not require Iterative redesign process, therefore provides excellent convergence and efficient computing. Tool design In ECM mainly deals with predicting gap distribution for a given work-piece shape.

Yuming Zhou et al. [2] suggest a new approach for the problem like limited applicability, inaccuracy, and non-convergence occurred when tool (cathode) design in electrochemical machining has been overcomes by employing a finite element method with an optimization formulation.

S. Chang et al. [3] presented the effect of thermal fluid properties in the numerical simulation of the tool shape for given work-piece shape in electrochemical machining. A bubbly two-phase, one-dimensional flow model and a one-phase, two-dimensional flow model are applied to predict the fluid field of the electrolyte, respectively.

S. J. Ebeid et al. [4] studied the improvement of machining accuracy in ECM by hybridizing the process by low-frequency vibrations. The study highlights the development of mathematical models for correlating the inter relationships of various machining parameters such as applied voltage, feed rate, back pressure and vibration amplitude on overcut and conicity for achieving high controlled accuracy,

P. S. Pa [5] studied the most effective geometry for the design electrode in electrochemical smoothing following end turning is investigated. Through simple equipment attachment, electrochemical smoothing can follow the cutting on the same machine. When adequate work-piece rotational speed associated with higher electrode rotation produces better polishing.

A. K. M. De Sllva et al. [6] studied on precision ECM process, dimensional accuracy ±2 |im, surface finish 0.01 |im Ra, has been developed using narrow Inter-electrode gaps (< 50 |im) for mass production of small (100 mm2) component parts. The electrolyte properties, especially the concentration, play a significantly role in controlling the dimensional accuracy of precision-ECM.

Petr NOVAK et al. [7] studied the influence of the electrolyte composition on intergranular corrosion of various nickel alloys and of hardenable stainless steel were investigated. The nickel-base alloys remained unaffected in a solution of 15 % + 20 % + 65 % but suffered intergranular corrosion in solutions of and Stainless steel showed no signs of intergranular attack in any of the electrolyte solutions used.

M.A. Bejar and F. Gutierrez [8] present the results of a study concerned with the determination of the current efficiency when high-speed steel is machined electrochemically with a sodium nitrate electrolyte. The tests were carried out without feed rate and at several inter-electrode voltages. The inter-electrode gap and the electrical current were measured simultaneously as a function of time

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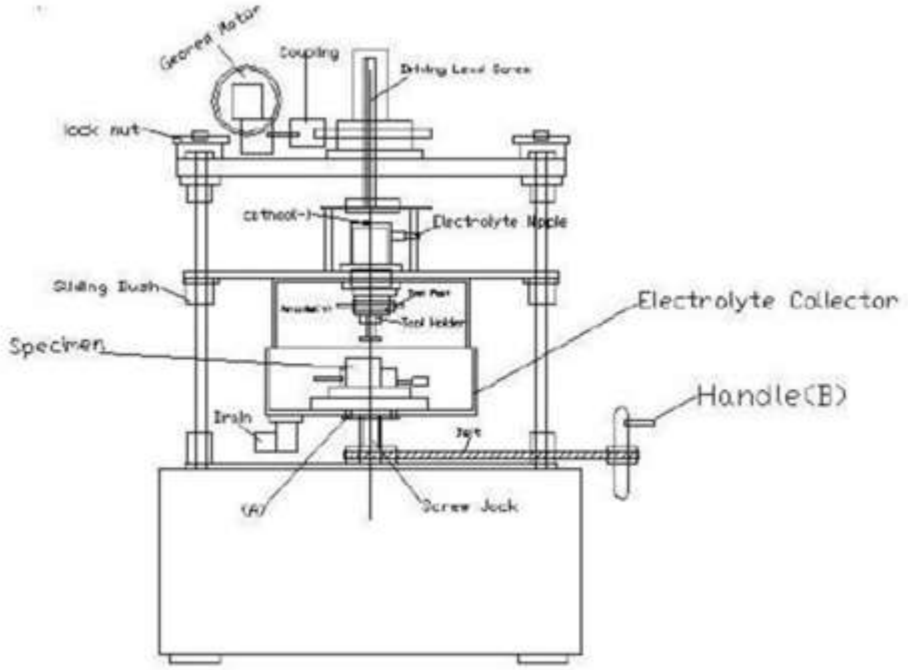
III. MATERIALS AND METHODOLOGY

To study the material removal rate (MRR), Overcut diameter and overcut depth of ECM, it is necessary to identify and understand the factors affecting the responses. The factor effecting the responses have been studied by conducting series of machining experiments using AISI P20 tool steel as work-piece. AISI P20 tool steel have several properties like it's a pre hardened high tensile tool steel strength which offers ready machinability in the hardened and tempered condition therefore doesn't require further heat treatment. This eliminates the risk, cost and waiting time of heat treatment thus avoiding the associated possibility of distortion or even cracking. Schematic diagram of ECM is shown in Figure.



Experimental Setup

The whole experimental conducted on Electrochemical Machining set up from Metatech Industry, Pune which is having input Supply of - 415 v +/- 10%, 3 phase AC, 50 HZ. Output supply is 0-300A DC at any voltage from 0-25V and efficiency is better than 80% at partial and full load condition. The cable insulation resistance is not less than 10 Mega ohms with 500V DC. And consist of three major sub systems which are being discussed in this chapter. The set up consists of three major sub systems.

1. Machining setup
2. Control Panel
3. Electrolyte Circulation

IV. RESULTS AND DISCUSSION

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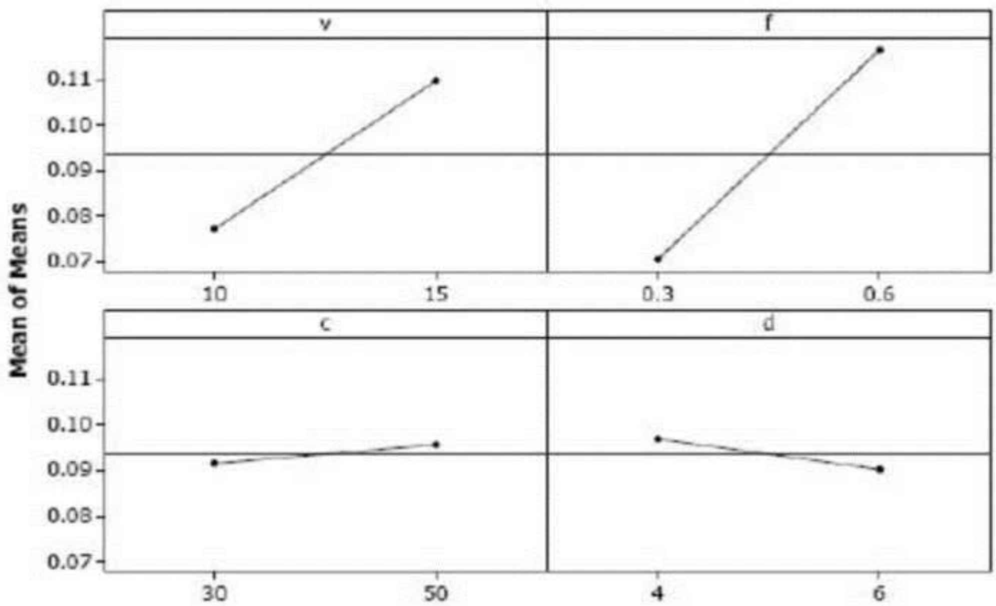
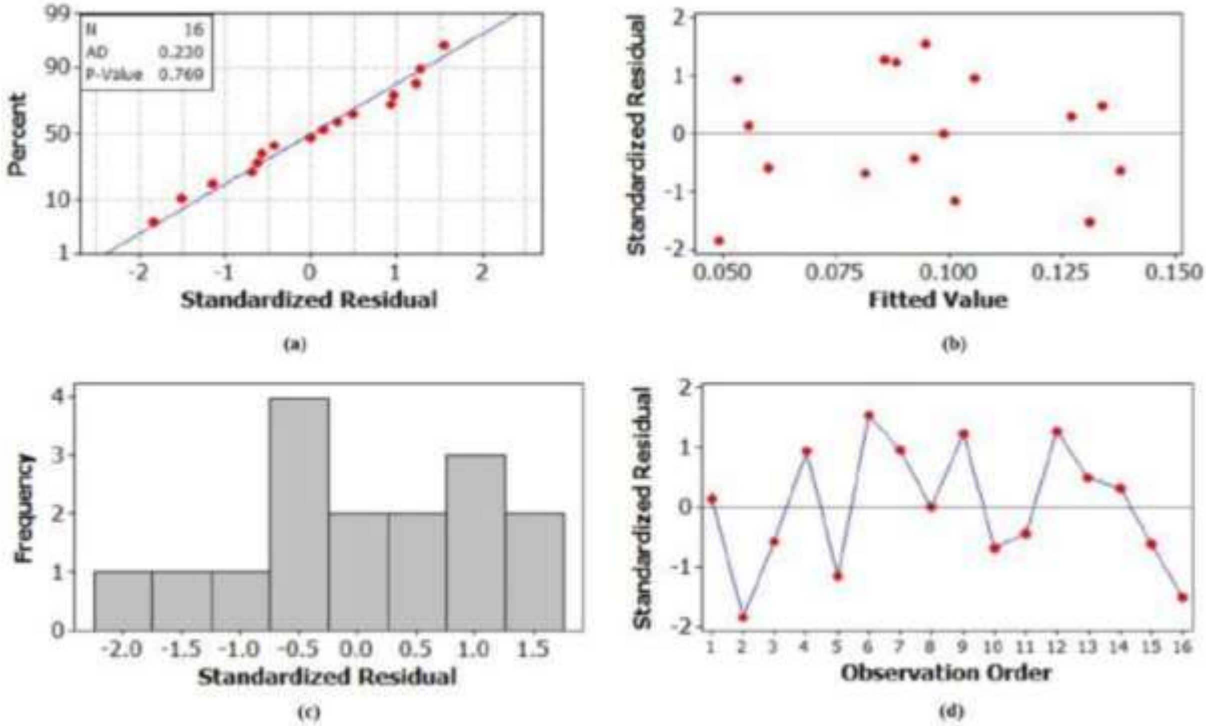


Main effect of plot for MRR 39

The work evaluates the feasibility of machining blind cavity on AISI P20 tool steel in ECM with Rotary U-shaped electrode. Among the four process parameters, feed rate influences highly the responses followed by voltage and then electrode diameter. Electrolyte concentration has very little effect on Response.



Residual plots for MRR (a) Normal probability plot (b) Residual vs Fitted plot
(c) Histogram of Residuals (d) Residuals vs Order of data plot

V. CONCLUSION

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In the present study, four factors are considered voltage, feed rate, electrolyte concentration and tool diameter. AISI P20 steel as a work-piece and 16 experiments to be conducted to obtain an optimum level in achieving high material removal rate, minimize OC-diameter and minimize OC-depth. The following conclusions are arrived:

- Among the four process parameters, feed rate influences highly the MRR, followed by applied voltage then electrode diameter and then by the concentration of electrolyte.
- For both OC-diameter and OC-depth the most influencing parameter are feed rate followed by electrode diameter then voltage and lastly the concentration of electrolyte.
- From the grey relation grade, the optimal machining parameter setting are obtained for Run 15 i.e. voltage = 15 V, feed = 0.6 mm/min, electrolyte concentration = 50 g/l and electrode diameter = 4 mm for maximizing MRR and minimizing overcut diameter and depth

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