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Study of Optimization Parameters in Electrochemical Machining Operation

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Abstract:
The machining of complex shaped designs was difficult earlier, but with the advent of the new machining processes incorporating in it chemical, electrical & mechanical processes, manufacturing has redefined itself. Electrochemical Machining is a non-traditional machining process which is used to machine difficult-to-machine materials such as super alloys, Ti-alloys, stainless steel etc. The basic working principle is based on Faraday law of electrolysis due to which the material removal takes place atom by atom by the process of electrolysis. This 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 undertaken 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 analyse 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.

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

I. 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 characterised 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 workpiece 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 workpiece 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 thin metallic films because 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.

II. LITERATURE REVIEW

B. Bhattacharyya et.al [1] 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. **Joao Cirilo da Silva Neto et.al [2]** demonstrates an investigation of of the intervening parameters in ECM. The parameters studied in this papaer are material removal rate (MRR), over-cut and hardness. **S K Mukherjee et.al [3]** 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. **K. P. Rajurkar et.al [4]** examined the important advantages of the ECM procedure, for example, high MRR, damage-free and smooth machined surface, are regularly counterbalanced by the poor control of dimension.

S.K. Mukherjee et.al [5] 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. **V.K. Jain et.al [6]** has reported that electrochemical spark machining method has been effectively used for cutting quartz utilizing a controlled feed and a wedge edged tool. **K.L. Bhondwe et.al [7]** 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.**R V Rao et.al [10]** 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.

Yuming Zhou et.al [12] 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. **Jerzy Kozak et.al [13]** 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..**K.P. Rajurkar et.al [14]** had demonstrated that ECM method now progressively used in other commercial enterprises where components with hard-to-cut materials and criticle shape are needed. **J.A. Westley et.al [15]** 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..**Chunhua Sun et.al [16]** 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 known work piece.

III. EXPERIMENTAL SETUP

In this chapter we will study about the experimental work which comprises of experimental set up, design of electrode, selection of work piece material, preparation of electrolytic solution and RSM method for stainless steel (AISI 304) specimen. By taking all this information in account we will calculate the material removal rate. Total 20 experimental runs have been done for RSM design and 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.MRR and surface roughness was measured. 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. 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.

The pumping of electrolyte is done from a tank. With the assistance of corrosion resistance pump, the tank is lined by corrosion resistant coating & is fed to the job. The spent electrolyte will return to the tank. The hydroxide sludge produced will settle at the base of the tank & can be drained out without difficulty. Governing of electrolyte supply is done by flow control valve. Generally non reacting material such as Copper is used as tool in ECM. To determine a cathode shape which will machine a specified work piece shape was objective in study of tool design problem in ECM. Cathode material taken in this experiment is made up of copper. In this test copper is taken as cathode material as cathode. It 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.

Figure. 1. ECM Setup

IV.EXPERIMENTAL WORK

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. I have taken 2 pieces of AISI 304 material and carried out the experiment .In one work piece 15 cavities are done while in second workpiece 5 experiments were done. And the corresponding material removal rate is evaluated by measuring initial and final weight of work piece before and after the experiment.

Table.1. Structure varieties for AISI 304 mark stainless steel

Machining parameter	Unit	Level		
		Level 1	Level 2	Level 3
Voltage (V)	volt	10	13.5	17
Feed rate (F)	mm/min	0.4	0.6	0.8
Concentration(C)	gm/lit	100	125	150

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