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Study of Machine Characteristics During Rotary EDM Machining using Tools Made of Aluminium Alloy 6061

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ABSTRACT

Electro discharge machining (EDM) is an unconventional machining process that uses spark energy to remove material from the workpiece. EDM process is extensively being used in die/mould making industries, automobile industry, aerospace industry etc. for generating complex and intricate shape on hard material.
Numbers of research works have been carried out using EDM process in order to improve the performance. Further, different variant of EDM process like dry EDM, orbital EDM, powder mixed EDM, ultrasonic assisted EDM and rotary EDM etc. have also been studied. Rotary EDM process is very promising process that helps to improve surface finish, overcut as well as out of roundness. In the present paper, a extensive review has been presented on rotary EDM process. Significance of several input parameters has been observed on output characteristics like overcut and out of roundness.
Keywords : EDM, Rotary, Overcut, Roundness

I. INTRODUCTION

Electrical-discharge machining (EDM) is an unconventional, non-contact machining process where metal removal is based on thermo-electric principles. In this process, the material removal mechanism uses the electrical energy and turns it into thermal energy through a series of discrete electrical discharges occurring between the electrode and work piece immersed in an insulating dielectric fluid. Electrical Discharge Machining (EDM) is a process of material removal using an accurately controlled electrical discharge (spark) through a small gap (approximately 10 to 50 microns) filled with dielectric fluid between an electrode and a work piece. The hardness of the work piece has no effect on the process. Electrically conductive material is removed by controlled erosion through a series of electric sparks of short duration and high current density between the electrode and the work piece, both the work piece and tool is submerged in a dielectric bath, containing kerosene or demineralized water. During this rotary EDM process thousands of sparks per second are generated, and each spark produces a tiny crater in the material along the cutting path by melting and vaporization. The objective of the present work is to find some suitable process parameters like overcut and out of roundness using aluminium alloy 6061 as a work piece s and round copper, copper tungsten electrodes as a tool and dielectric flushing during rotary electric discharge machining. The machining parameter selected are discharge current, and tool rpm, remaining all constant voltage pulse duration, fluid pressure of the tool analysing the responses of over cut and out of roundness.

An EDM cavity is always larger than the electrode used to machine it. The difference between the size of the electrode and the size of the cavity (or hole) is called the overcut. Many studies have evidenced that the rotation of the electrode is affected on EDM performance. Rotary electrical discharge machining (REDM) with different flushing techniques on Al_2O_3/6061Al composite material and studied their effect on MRR, electrode wear rate (EWR), and surface roughness (SR). They also used tubular, solid and electrode with eccentric hole for experiments. A metal matrix composite as work piece material and investigated the variation of machining feed rate and surface roughness with machining parameters. The rotary motion of the work piece helps in better circulation of dielectric fluid through the sparking gap and improves the MRR. REDM with a hollow tube electrode for drilling of the SiCp/6025 composite.

II. METHODS AND MATERIAL

The rotary motion of the work piece helps in better circulation of dielectric fluid through the sparking gap and improves the MRR. REDM with a hollow tube electrode for drilling of the SiCp/6025 composite. They reported that the rotary electrode improved the MRR, and also, the EDM drilling with the tube electrode has a higher MRR and lower EWR and SR with respect to injection flushing. The machining factors of wire EDM process using the Taguchi method for maximizations of MRR and minimization of surface roughness. The analysis showed that factors like discharge current, pulse duration, and dielectric flow rate have been found to play a significant role in cutting operations. Analysis for improvement of the machine output during electrical discharge machining by introducing an induced magnetic field on the work piece during REDM of EN-8 steel with a rotary copper electrode. The feasibility of fabricating micro holes in SiCp–Al composites using micro-electro-discharge machining with a rotary tube electrode. The experimental results show that servo-speed significantly affects the MRR and EWR, while pulse on duration affected the taper.

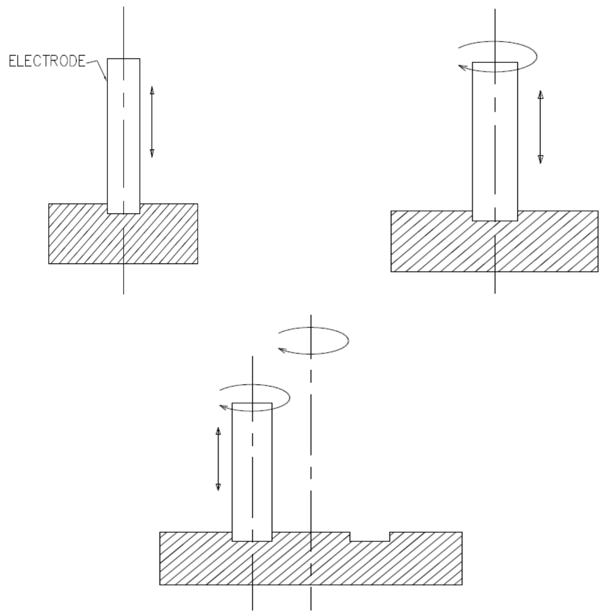

Fig 1. Electro-discharge machining with Stationary electrode (b) rotating electrode (c) rotating electrode with orbital motion .

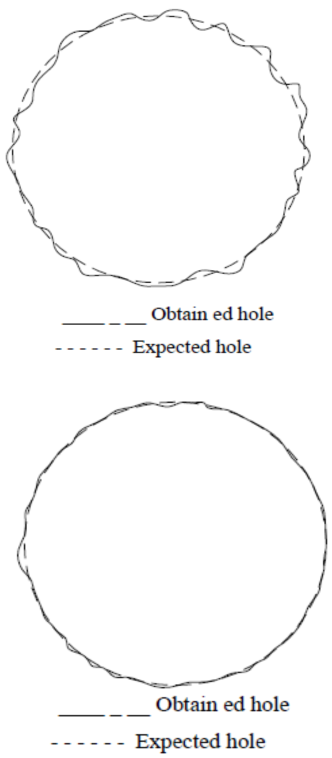

Fig:2 Out –of –roundness with and without rotating electrode

III. EXPERIMENTAL RESULTS

TABLE 1

Work & Tool material properties

Work materials	Aluminium Alloy 6061
Work shape & size	50x50x10mm
Density	2.7 g/cm³
Hardness	95BHN
Tool materials	Copper &Copper Tungsten
Tool shape & size	Cylindrical shape of dia3mm
Density	14700Kg/m³
Hardness	170 BHN

Process Parameters	
Dielectric	Demineralised Water
Voltage	90 V
Current	60A, 70A & 80A
On pulse duration	20
Electrode rotating speed	0rpm, 500rpm, 750rpm & 1000rpm
Type of machining	Through hole machining

IV. EXPERIMENTAL RESULTS

EDM System Specification And Test Conditions

Equipment	3D micro EDM SX 200 HPM
Open circuit voltage	90V
Discharge current	60, 70,80 Amperes
Pulse on duration	20µs
Electrode rotation	0,500,750 and 1000 rpm
Servo control	Electro- hydraulic
Type of machining	Through hole

The micro EDM with servo control & rotating aids with variable speeds for electrode was used to conduct the experiments. Table 1 gives the properties of the materials used & their process parameters.

V. MEASUREMENTS

Eroded hole diameter was measured using optical microscope. The electrode diameter was measured with micrometer which had a least count of 0.001mm. The magnification used for the photographs of the holes was (x16) on a metallurgical microscope. Taly Rond was used to measure out of roundness at a magnification of (x500).

VI. DESIGN OF EXPERIMENTS

The experiment work was planned on the basis of statistical design of experiments. The scheme of experiment plan, along with the factors & their coded levels are as given in the table 2.

The total number of regression coefficients is represented as N & is given by the expression:

$$N = n(n+3)/2 + 1$$

Where n is the number of factors.

TABLE : 2

The scheme of experiment plan along with the factors & their coded levels.

Response	Factors	Code levels			Remarks
		-1	0	1	
Overcut (mm)	X1 Current (amp)	60	70	80	Pulse duration constant
Out of roundness (µm)	X2 Electrode rotation (rpm)	500	750	1000	

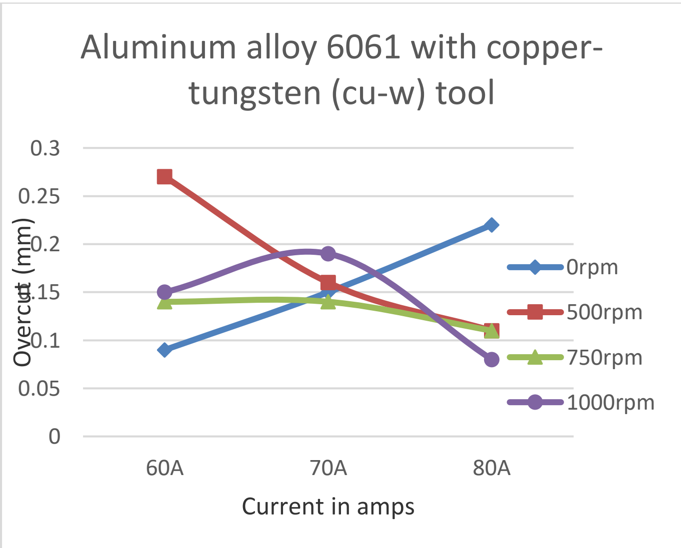

Fig 1. Aluminum alloy 6061 with copper –tungsten tool current Vs over cut .

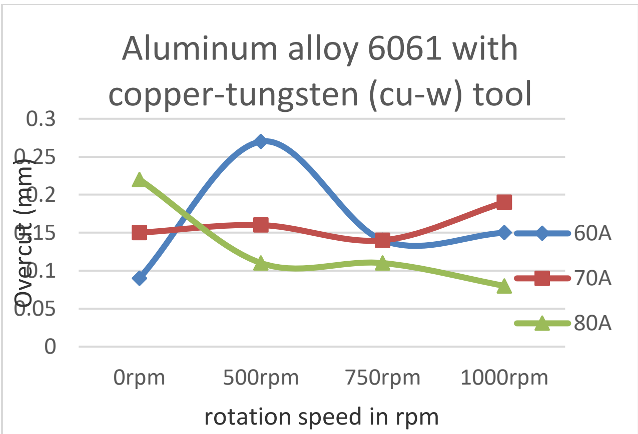

Fig 2. Aluminum alloy 6061 with copper –tungsten tool rotational speed Vs over cut .

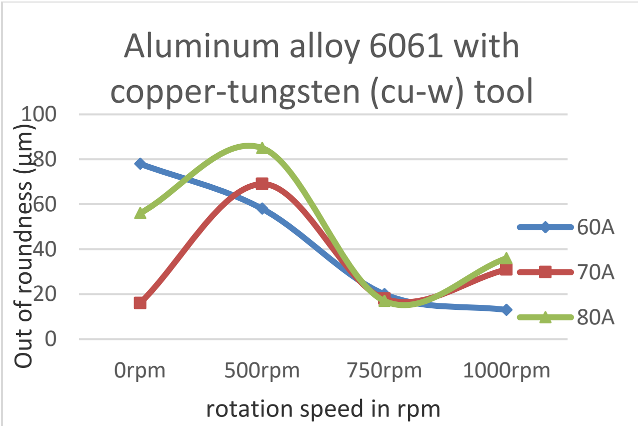

Fig 3. Aluminum alloy 6061 with copper –tungsten tool rotational speed Vs out of roundness .

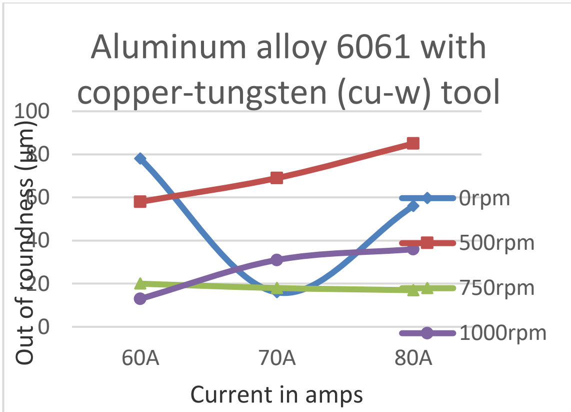

Fig 4. Aluminum alloy 6061 with copper –tungsten tool current Vs out of roundness

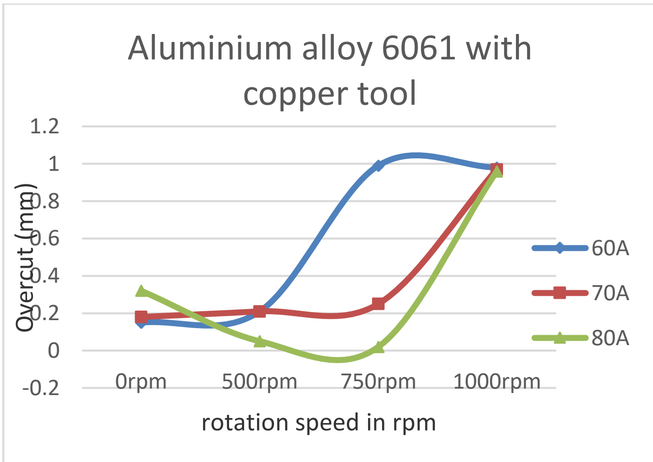

Fig 5. Aluminum alloy 6061 with copper tool rotational speed Vs over cut

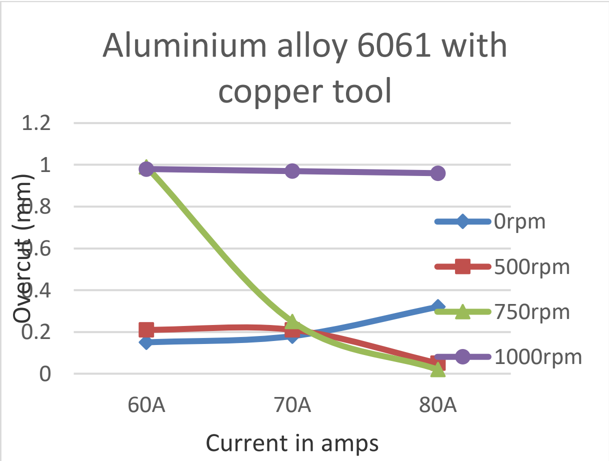

Fig 6. Aluminum alloy 6061 with copper tool current Vs over cut

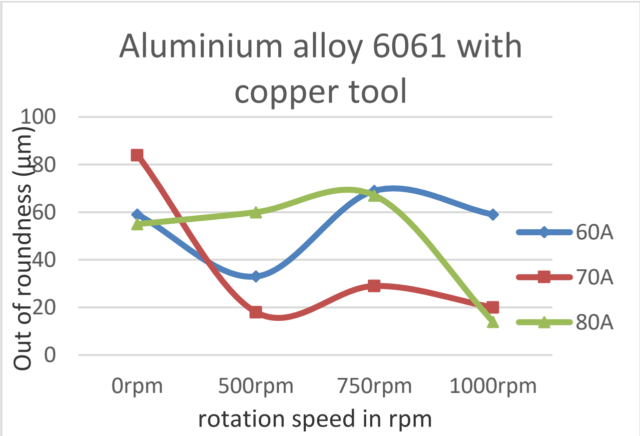

Fig 7. Aluminum alloy 6061 with copper tool rotational speed Vs out of roundness

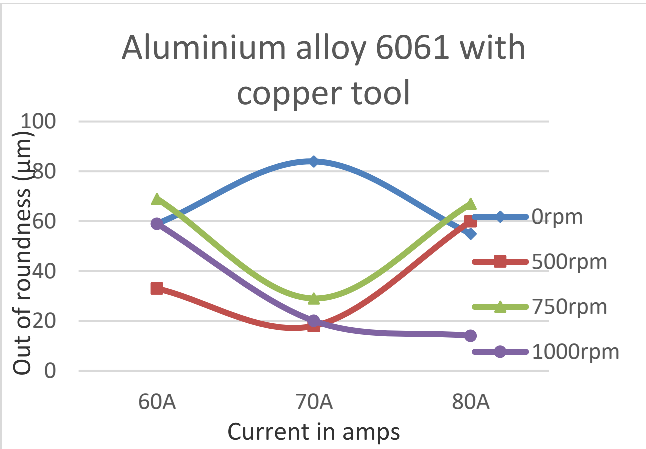

Fig 8. Aluminum alloy 6061 with copper tool current Vs out of roundness

VII. CONCLUSIONS

The research of the present work is summarized experiments were conducted to study the individual effects and optimize the Micro-EDM process parameters. From the experiment the following are the conclusions drawn from the present investigations. Based on the results and discussions the following conclusions are made.

1. Rotary EDM improves out-of roundness due to improved flushing.
2. The rotary mode of EDM is better than stationary mode of Machining of 3mm hole at 750 rpm is recommended.
3. Over-cut and out of roundness increase with increasing current
4. It is concluded that rotation of electrode improves out-of-roundness, overcut and out-of-roundness increase with increase of current with both rotating and stationary electrodes.
5. Overcut for aluminium alloy with copper and copper tungsten tool as shown in the above graph provides better overcut values at speeds of 500rpm to 750rpm for all the current values.

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