Design of electrode in electrochemical machining for surface reduction at rotary position of work piece with different shape of tools use.

Rahul Pachoriya[1]
[1]M.Tech. Final Year, Department of Mechanical Engineering, MITS, Gwalior
Manish Gangil[2]
[2]Assistant Professor, Department of Mechanical Engineering, GIIT, Gwalior
Om Prakash Mishra[3]
[3]M.Tech. Final Year, Department of Mechanical Engineering, MITS, Gwalior

Abstract:
In this paper, the most effective geometry for the design electrode and the advantage of the low cost equipment in electrochemical smoothing surface reduction at rotary position of work piece. Through simple equipment attachment, electrochemical smoothing can follow the cutting on the same machine. An adequate work piece rotational speed associated with higher electrode rotation produces better surface finishing. The effective design of electrode attaché in electrochemical machine, in this attachment the tool position is perpendicular of the work piece. which cut the material smoothly and good surface finish have an optimal value for higher current density and provides a minimum discharge space, It can be increase the mass production with the help of this experimental design of electrode. It can be design the pen's nib, design the bullet of the gun, medical surgery equipment and also make the different complicated part of the machine etc.

***Keywords*:** *Electrode design, Electrochemical smoothing, surface reduction.*
*Corresponding author**. rahulkp47@gmail.com**, +91-9977672396

1. Introduction

Electrochemical machining is one of the most potential unconventional machining processes. Though it is a new process for metal working, the basic principle had been well-known for a long time. This process may be considered as the reverse of electroplating with some modifications. Further, it is based on the principle of electrolysis. In a metal, electricity is conducted by the free electrons, but it has been established that in an electrolyte the conduction of electricity is achieved through the movement of ions. Thus, the flow of current through an electrolyte is always accompanied by the movement of matter.

Michael Faraday discovered that if two electrodes are placed in a bath containing a conductive liquid and D. C. potential is applied across them, metal can be depleted from the anode and plated on the cathode. This principle was use for a long time in a process called 'Electroplating'. With certain modification, ECM is reverse of electroplating.

ECM uses a shaped tool or electrode. Since the term 'machining implies' the removal of material from the work-piece, the tool is made the cathode and the work-piece the anode. An electrolyte is pumped through the small gap which is maintained between the tool and work-piece.

2. Literature Review

The principle of ECM was presented by Faraday in the 18th century. The work-piece is made from the anode of an electrolytic cell. The tool is made from the cathode and is maintained at a gap of tenths of a millimeter from the work-piece. An electrolyte is pumped between the gap while a large direct current is passed across, and the material of the work-piece is removed by electrolytic dissolution of the anode (McGeough, 1988). Gusseff first filed a patent on electrochemical machining (ECM) in 1929 and found that ECM is suitable for high-strength and high-melting point alloys (1988). Electrochemical machining has been known to be a highly effective metal removal method for machining hardened metals without producing the process-induced stress and wear of the machining tool (Hoare and LaBoda, 1969).

The material removal rate per unit area (feed rate) is proportional to the current density multiplied by the current efficiency, and the feed rate of the electrode (Louter and Cook, 1973). Bannard correlates the current efficiency with the current density and flow rate of the electrolyte. The maximum efficiency varies with the type of electrolyte (Bannard, 1977). Noto et al. (1973) put forward the study of the electrode gap using sodium nitrate solution. Datta and Landolt (1981) showed that the gap width between the electrode and work-piece directly influences the current condition and the dreg discharge of the electrolyte. Electro polishing can efficiently produce work pieces of good surface finish (Masuzawa, 1987). It is very suitable for difficult-to-machine materials. Plastic or press dies, wire-drawing dies, optical and electric parts can apply this technique as well (Phillips, 1986).

The electrochemical honing of cylindrical holes improves the dimensional accuracy and relieves the surface layer stress (Budzynski and Landolt, 1986). Bejar et al. (1993) changed the machining gap width as well as the concentration of electrolyte to investigate the influence upon current efficiency. They found that current efficiency is raised with the increase of current density and electrolytic concentration. When voltage is increased, overcut is also increased, and the current passed between anode and cathode becomes higher (Fadaie-Tehrani and Atkinson, 1995).

More industrial applications were realized throughout the decades, such as electrochemical drilling, electrochemical grinding, electrochemical debarring, and electro polishing (Wilson, 1971). Electrochemical machining won more attention in industrial application, and the process became an important method of metal removal (Gurklis, 1965).

3. Experimental Setup and Methodology

The development of a design electrode in electrochemical machining for surface finishing is based on the following considerations:

3.1 Cost saving of subsequent electrochemical smoothing: The electrochemical smoothing of turning surface finishing should follow turning to reduce the cost of the production cycle, since the electrode will set-up on the tail stock of the same lathe. No expensive manufacturing technique should be required for the implementation of the electrode design.

3.2 Increase in electric current density: A good electrode design should provide electrochemical smoothing, adopting sufficient electrical current density for a faster polishing rate and better polishing effect in the operation.

3.3 Reduction of secondary machining: To ensure the dimensional and geometrical accuracy of the polished surface, the secondary over cut induced by the working gap should be eliminated as soon as possible.

3.4 Effective discharge of the electrolytic product: The discharge of the electrolytic product out of the gap is crucial for polishing. The considerations of small wedge angle and small edge rounding radius will be incorporated into the electrode design.

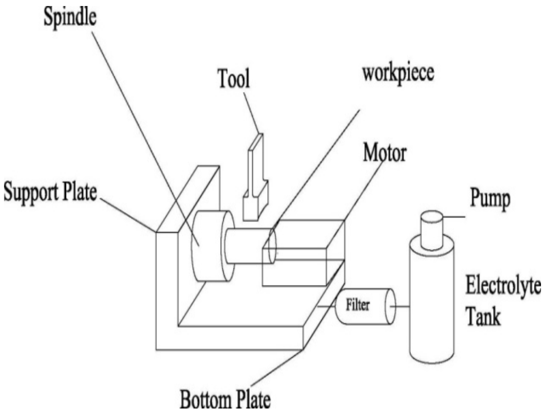

Fig.1 Imaginary view of design of electrode

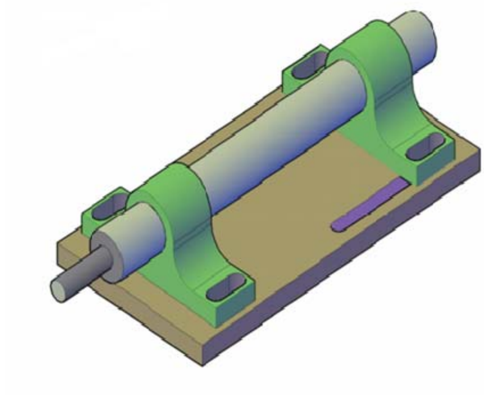

Fig.2 Solid view of design of electrode

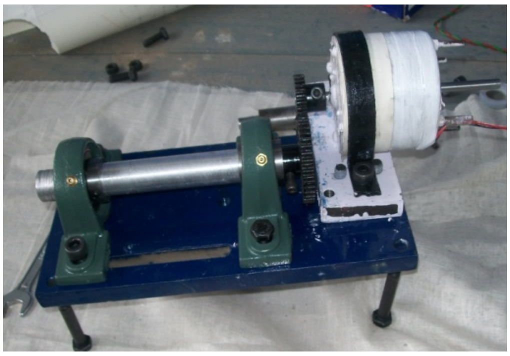

Fig.3 Final view design of electrode

Fig.4 Experimental set-up system

The development of the electrode design with experimental set-up is schematically illustrated in Figure.4. The materials of the work piece are mild steel. The dimensions of the work piece are 28mm in diameter and 130 mm in length. The alternative to electrochemical smoothing is the so-called electro brightening. The amount of the reduction of materials of the phase following electrochemical smoothing and electro brightening varies between 0.1 to 10 mm depending on the polishing time. This method requires the phase to have precise turning in advance. The average surface roughness after precise turning is around 0.1 mm instead of 10 mm following rough turning. The initial average surface roughness of the work piece from turning is 0.1 to 10 mm, the aim is to reduce the value to below 10 mm.

The main parameters include the geometry of the electrode, die material, and the rotational speed of the work piece and electrode. The electrolyte is Na_2So_4 of 25 wt% The reason for using Na_2So_4 is that it is quite stable and suitable for a certain amount of material removal eliminating the need for complicated pre-polishing of work piece. The flow rate of electrolyte is 4 L/min. The gap width between the electrode and work piece is set at 0.3 mm. The current density is 30 A/cm^2. The rotational speed of the work piece is 200, 400, 600, 800, 1000, and 1200 rpm. All work pieces after electrochemical smoothing are measured by the surface roughness measurement

Table. 1 Component of machine

S.N.	Component of machine	No. of Component	Material	Weight	Total cost = material cost + manufacturing cost
1	Bottom Plate	1	Mild Steel	3.6 kg	2000 Rs
2	Pedestal Bearing	2	Cast Iron	1.4 kg	250 Rs
3	Gear	2	Cast Iron	360 gm	160 Rs
4	Motor	1		1.2 kg	250 Rs
5	Motor Plate	1	Mild Steel	600 gm	460 Rs
6	Motor Clamp	1	Cast Iron	150 gm	75 Rs
7	Rod	2	Mild Steel	1.5 kg	575 Rs
8	Nuts & Bolts	16 & 4	Mild Steel	600 gm	200 Rs

4. 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. The tool is made hollow for drilling holes so that electrolyte can pass along the bore in tool.

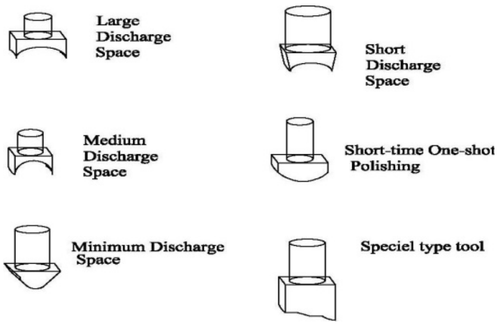

Fig.5 Development of Tool Design

Fig.6 Different shapes of tools

5. Result and Discussion

The experiment is divided into three parts. The first part investigates the effects of the primary experiment of the geometry design of the electrode in the electrochemical smoothing process; the second part is the surface reduction of the work piece with turning process. The third part is the experiment setup the surface reduction with design of the different shaped of tools use.

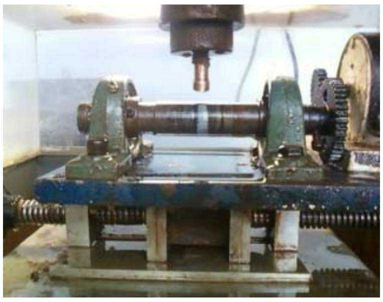

Fig.7 surface reduction after the electrochemical smoothing turning process

Table.2 Electrochemical machining at interval of (0.1-0.9) mm surface reduction with different shape of tool use with rotating work piece.

Depth of cut (mm)	Flat Shaped Tool Mass reduction(gm)	U-Shaped Tool Mass reduction(gm)	V-Shaped Tool Mass reduction(gm)
0.1	0.9116	0.9158	0.9168
0.2	0.9031	0.9146	0.9160
0.3	0.8951	0.9128	0.9148
0.4	0.8886	0.9106	0.9132
0.5	0.8766	0.9080	0.9114
0.6	0.8698	0.9048	0.9090
0.7	0.8579	0.9008	0.9060
0.8	0.8486	0.8956	0.9025
0.9	0.8345	0.8891	0.8980

Fig.8, 9 and 10 Mass reductions at 0.1mm interval depth with rotating work piece with the flat shaped, U shape and V shape tool use,

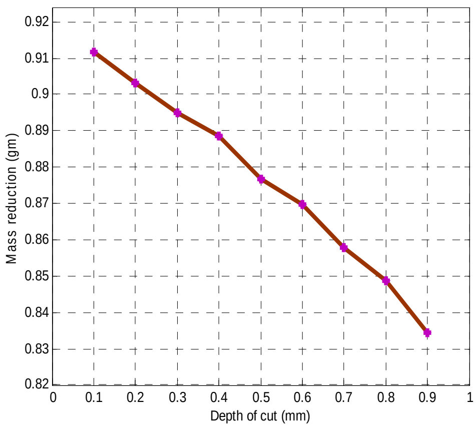

Fig.8

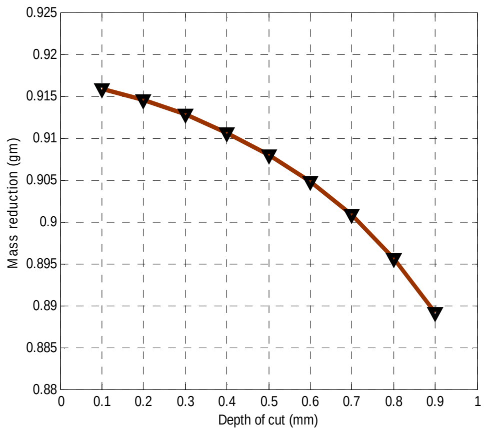

Fig.9

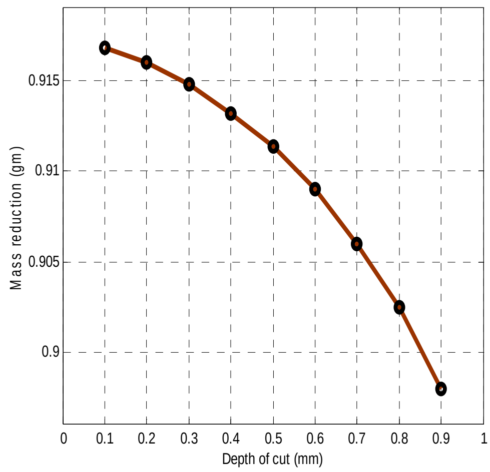

Fig.10

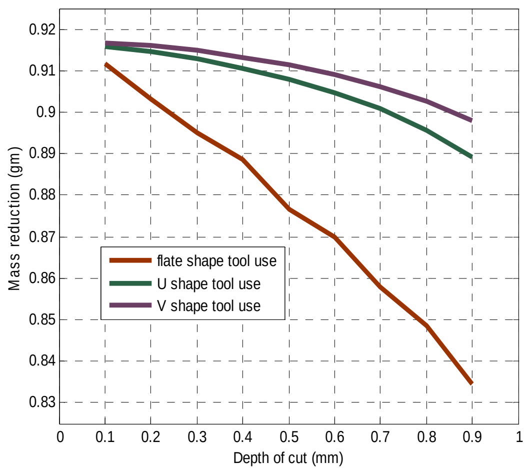

Fig.11

The flat type tool use in experimental design, the large discharge space of electrolyte flow, a large area to be cut the material remove. In this shaped of the tool large discharge space with chamfer to corner .with the help of in this tool shaped to de design different type of parts of machines.

Fig.11 Comparison of electrochemical smoothing at 0.1mm surface reduction with rotation of work piece with different shaped of the tools use

The different tool use in this experimental setup then different material removes with respect to the depth of cut. The flat shape tool as large discharge space, the U-shape tool as chamber for discharge space and the V-shaped tool as less discharge space the increasing order of material remove with different shaped of the tool.

V-shaped < U-shaped < Flat shaped

Material removal rate with different speed of the work piece. When the speed of the work piece are low then the highly surface reduction of the work piece. Surface finishing smoothly with low speed.

6. Conclusion

Electrochemical smoothing following traditional phase turning by a design electrode is demonstrated. Higher electrical current is not required when an effective design electrode is used to reduce the response area instead of the mate-electrode, as in conventional ECM. This process can be used for various phase turning operations. Through simple equipment attachment, electrochemical smoothing can follow the cutting on the same machine and chuck. Adequate work piece rotation speed and the tool as perpendicular position of the work piece which is material removal easily with phase turning process are found in the present case. In case stationary position of work piece the material removal highly under depth cut only it does not given better surface finishing than rotary work piece attachment electrode. It can only cut material one side of work piece. It can be cut easily marking symbol, hole on the rectangular, cylindrical work piece. But it cannot cut efficient design cut on the cylindrical work piece. It may be possible in a simple attachment design of electrode where the work piece rotates in the electrochemical machining.

7. Future scope

It can be increase the mass production with the help of this experimental design of electrode. It can de design the pen’s nib, design the bullet of the gun, medical surgery equipment and also make the different complicated part of the machine etc. Electrochemical smoothing saves the need for precise turning, making the total process time less than the electro brightening. But the electro brightening after precise turning only requires quite a short time to make the work piece bright.

The technique can be applied to a variety of metal products in the automotive, aerospace, medical, jewellery industry, printing industry, textile industry, energy industry and various other sectors. The technique is also frequently utilized for very specific micro applications.

8. References

[1] Azcue, J.M., 1995. Comparison of different cleaning procedures of root material for analysis of trace elements. Int. J. Environ. Anal. Chem. 62, 137–145.

[2] Ban nard, J., 1977. Effect of flow on the dissolution efficiency of mild steel during ECM. J. Appl. Electrochemical. 7, 267–270.

[3] Bejar, M.A., et al., 1993. On the determination of current efficiency in electrochemical machining with a variable gap. J. Mater. Proc. Technol. 37, 691–699.

[4] Budzynski, A.F., 1986. Electrochemical Honing-Studies on Shape Precision of Holes Being Processed ISEM-VIII, Moscow, pp. 155–161.

[5] Chin, D.-T., Mao, K.-W., 1974. Transpassive dissolution of mild steel in NaNO3 electrolytes. J. Appl. Electrochem. 4, 151–161. Datta, M., Landolt, D., 1981.

[6] Datta, M., Landolt, D., 1981. Electrochemical machining under pulsed current conditions. Electrochim. Acta 26 (7), 899–907.

[7] Davidson, A.W., Jirik, F., 1950. Anodic oxidation of elements of the aluminum sub-group in anhydrous acetic acid. J. Am. Chem. Soc. 72 (4), 1700–1705.

[8] Evans, U.R., 1960. Corrosion and Oxidation of Metals. Edward Arnold, London, p. 883.

[9] Electrochemical machining under pulsed current conditions. Electrochim. Acta 26 (7), 899–907. Datta, M., Landolt, D., 1983.

[10] Electrochemical saw using pulsating voltage. J. Appl. Electrochem. 13, 795–802. Fadaie-Tehrani, A., Atkinson, J., 1995. A Study of Pulsed Electrochemical Grinding ISEM-XI, pp. 543–552.

[11] Gurklis, J.A., 1965. Metal removal by electrochemical methods and its effect on mechanical properties of metals, Battelle Memorial Institute, Defense Metals Information Center, DMIC Report 213.

[12] Hoare, L.P., LaBoda, M.A., 1969. An investigation of the difference between NaCl and NaClO3 as electrolytes in electrochemical machining. Electrochem. Sci., 199–203.

[13] Hardisty, H., Milehan, A.R., Shirvani, H., 1993. Finite element simulation of the electrochemical machining process. CIRP Ann. – Manufact. Technol. 42 (1), 201–204.

[14] Hocheng, H., Pa, 2000. Ring-form electrode in electro polishing of external cylindrical surface. Int. J. Electr. Mach. l.5, 7–15.

[15] Hocheng, H., Pa, P.S., 2001. Electrode form design and ultrasonic aid in electro polishing of holes. Int. J. Electr. Mach., 33–39.

[16] P.S. Pa 2008. Effective form design of electrode in electrochemical smoothing of end turning surface inishing journal of materials processing technology 1 9 5. 44–52