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Improving Machining Performance of ECM by Different Tool Geometry

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Abstract
Electrochemical machining (ECM) is a method of removing metal by an electrochemical process. The hard machine materials like high nickel, Cobalt, and titanium alloys can be machined by nonconventional machining. HC HCr dies steel is one of the hardest materials which are very difficult to machine using conventional machine tools because of its hardness values. Also, if used, the wear rate of the tool will be very high. Material removal is achieved by electrochemical dissolution of an anodically polarized workpiece, which is one part of an electrolytic cell in ECM. Hard metals can be shaped electrolytically by using ECM, and the rate of machining does not depend on their hardness. The tool electrode used in the process does not wear, and therefore soft metals can be used as tools to form shapes on harder workpieces, unlike conventional machining methods. The process is used to smooth surface, drill holes, form complex shapes, and remove fatigue cracks in steel structures. The Literature survey says that when velocity is directly proportional to MRR (Material Removal Rate). So we desired to improve the velocity of the electrolyte. The electrolytes pass through the tool holes. To enlarge the tool diameter 1 mm to 3 mm, finally, compare the experimental result of 1 mm and 3 mm diameter multi-jet tool. Which one are yield better MRR and Minimum surface roughness?

Keywords: *MATERIAL REMOVAL RATE, ECM, ELECTROLYTE*

I. INTRODUCTION

Conventional machining relies on direct mechanical contact between the tool and the workpiece, which often causes undesired changes in workpieces' properties, such as residual mechanical and thermal stresses. Rising production costs dictate that production operations be automated whenever possible. Innovative materials such as super-alloys, high carbon high chromium die tool steel, conductive composites, and many other advanced materials are difficult to or cannot be processed by conventional machining methods Material Removal Rate (MRR).

A. MATERIAL REMOVAL RATE

The rates at which metals can be electrochemically machined are proportional to the current passed through the electrolyte and the elapsed time for that operation, an inverse proportion to the electrochemical. Environmental considerations require the development of environmentally conscious processes. In this project work, find out the maximum material removal of high carbon high chromium die steel. Normally in ECM was NaCl used, Aqua solution as the electrolyte. ECM's influence parameter is voltage, feed rate, electrolyte flow per minute, and electrolyte concentration. We have focused on tool geometry to improve Material Removal Rate (MRR) of HC HCr with low Roughness, and Aqua mixed NaCl as Electrolyte.

B. ELECTROCHEMICAL MACHINING

The electrochemical machining system is used in this work. The workpiece was fixed between two metal sacrifice plates to minimize the over-cut at both sides of the machined hole. During the process, the electrode (tool) makes the feed movement while the workpiece is stationary. The tool material used was copper.

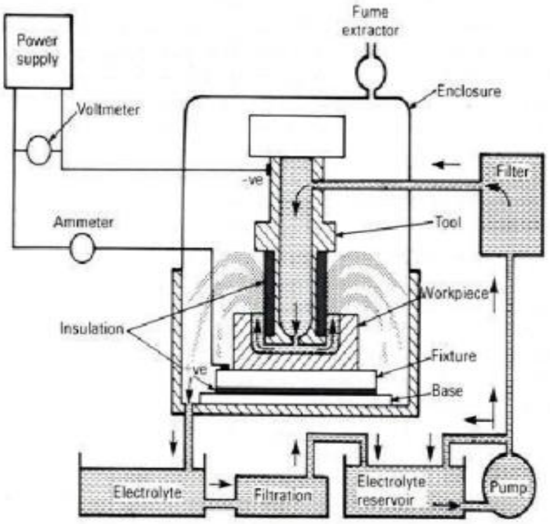


Fig 1: ECM Set Up

It was used in sodium chloride solution (NaCl at a concentration of 100 g/l). The following equation was used to calculate the material removal rate, considering a workpiece density of 7.8 g/cm3. Here, the workpiece and tool are anode and cathode, respectively, separated by an electrolyte. When an electric current of high density and low voltage is passed through the electrolyte, the anode workpiece dissolves locally. So the final shape of the generated workpiece is approximately a negative mirror image of the tool. When a potential difference is applied across the electrodes, several possible reactions can occur at the anode and cathode. The salt is not consumed in the electrochemical processes; therefore, it may be necessary to add more water for keeping a constant concentration level of electrolyte. This metal-electrolyte combination occurs due to electrolysis, the dissolution of iron from the anode, and hydrogen generation at the cathode.

II. OBJECTIVES OF ECM

The main objectives of ECM are the equivalent of the anode-metal. Many factors, other than current, influence the rate of machining. These involve electrolyte type, rate of electrolyte flow, and some other process conditions.

The basic operating parameters of ECM are

Experimental Details	
Voltage	12 V,15V,18V
Current	0 – 280 A
Current density	0 – 25 A/cm2
Inter electrode gap	0.1mm
Feed rate range	0.1,0.32 & 0.54
Power supply – DC	Continuous
Electrolyte flow rate	8, 10 & 12 lpm
Electrolyte type	NaCl aqua solution
Electrolyte	200 g/l
Tool material	Copper
No of the tool used	2
No. of holes in the tool	9 xø1 & 9xø3 mm
Electrolyte temperature	20-30o c
Workpiece	HCHCr Steel
Machining time	3 Min

III. EXPERIMENTAL OBJECTIVES

To study ECM's current efficiency, it is necessary to identify and understand the factors affecting the current efficiency. The factors affecting the current efficiency have been studied by conducting a series of machining experiments using nickel alloy as a work piece. Nickel alloys have several applications, including high-temperature-resistant applications, shape-memory applications, and wet corrosion applications, such as exhaust nozzles, nickel foams, solid-oxide fuel cells. The experimental setup of the ECM has been shown. The effect of the different process parameters such as the electrolyte and its flow rate, current density, duty cycle, and pulse on-time has been studied. It has been reported in the following chapters. The results have been analyzed.

A. TOOL FEED RATE

In the ECM process gap, about 0.01 to 0.07 mm is maintained between tool and workpiece. For smaller gaps, the electrical resistance between the tool and work is least, and the current is maximum, and accordingly, maximum metal is removed. The tool is fed into the work, depending upon how fast the metal is to be removed. The movement of the tool slide is controlled by a hydraulic cylinder giving some range of feed rate.

B. FACTOR INFLUENCING CURRENT EFFICIENCY

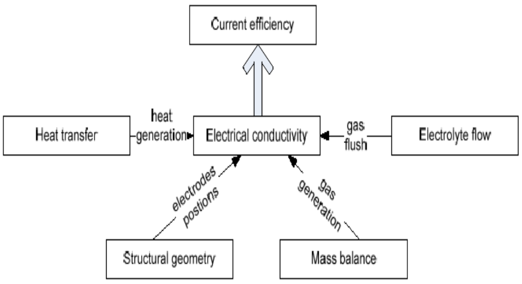
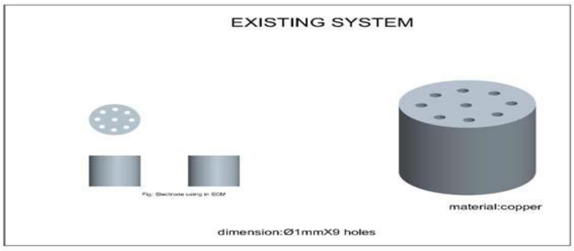


Fig 2: Factors Influencing Current Efficiency

C. TOOL SETUP

The purpose of the experimental investigation was to find out the Material removal rate workpieces. The tools were made up of copper. It is an abridged general view of the experimental system. The experimental conditions are: the electrolyte is sodium chloride, the electrode gap between the tool and workpiece is 0.1 to 0.3 mm, the workpiece is 100 mm diameter and 50 mm thickness, and the cathode is copper. When the experiment is carried out, the electrolyte should be at room temperature each time, and after the experiment, the electrolyte's conductivity must be checked.

Single Jet Tool is mostly used for small machining operations. This tool will take more time to machine a small area. The machining time will increase so that the production rate will decrease in this single jet tool. By using a single jet tool, we cannot be able to machine critical shape objects. To avoid all these drawbacks, the Multi Jet Tool is used.



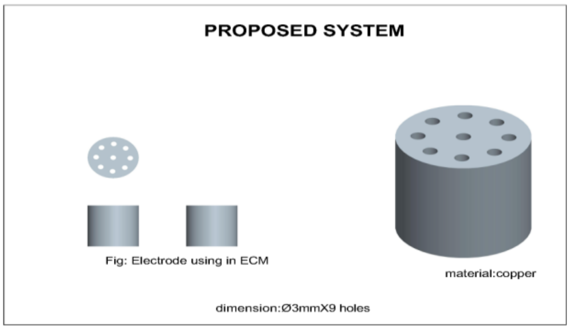


Fig 3: Existing and proposed system (tool design)

D. APPLICATIONS

Most copper is used for electrical equipment (60%); construction, such as roofing and plumbing (20%); industrial machinery, such as heat exchangers (15%) and alloys (5%). The main long established copper alloys are bronze, brass (a copper-zinc alloy), copper-tin-zinc, which was strong enough to make guns and cannons, and was known as gunmetal, copper, and nickel, know n as cupronickel, which was the preferred metal for low -denomination coins.

Copper is ideal for electrical wiring because it is easily worked and drawn into a fine wire and has a high electrical conductivity.

ECM technique removes material by the atomic level dissolution of the same by electrochemical action. Thus, the material removal rate or machining is not dependent on the work material's mechanical or physical properties. It only depends on the atomic weight and valency of the work material and the condition that it should be electrically conductive. Thus ECM can machine any electrically conductive work material irrespective of their hardness, strength, or even thermal properties. Moreover, as ECM leads to atomic level dissolution, the surface finish is excellent with an almost stress-free machined surface without any thermal damage. ECM is used for

- Die sinking
- Profiling and contouring
- Trepanning
- Grinding and drilling and micro-machining

IV. MODELING OF MATERIAL REMOVAL RATE

Material removal rate (MRR) is an important characteristic to evaluate a non-traditional machining process's efficiency. In ECM, material removal takes place due to the atomic dissolution of work material. Faraday's laws govern electrochemical dissolution.

The first law states that the amount of electrochemical dissolution or deposition is proportional to the amount of charge passed through the electrochemical cell, which may be expressed as:

$M \alpha Q$

Where m = mass of material dissolved or deposited

Q = amount of charge passed

Material Removed= Before Machining – After machining (gms)

Material Removal Rate (MRR) (mm^3/min) = (Material Removed*1000)

Density of Material (7.8g/cc)*Time (3minutes)

A. COMPOSITION of HC HCr STEEL

S.No.	**C**	**Mn**	**Si**	**S**	**P**	**Cr**
	In percentage %					
1	1.93	0.27	0.48	0.089	0.044	11.84

V. RESULT AND DISCUSSION

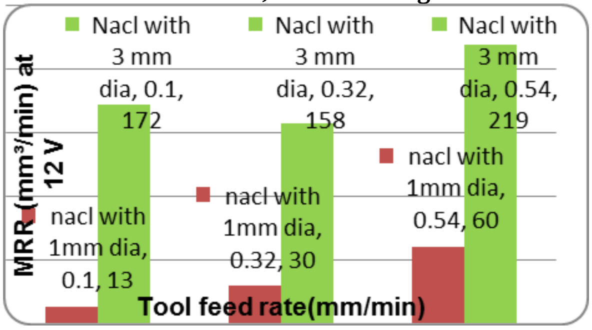
The following tables show the machining values after machining MRR, surface roughness, percentage of Overcut, current consumption, and energy consumed to remove material from the workpiece.

Material removed= Before Machining- After Machining (gms)

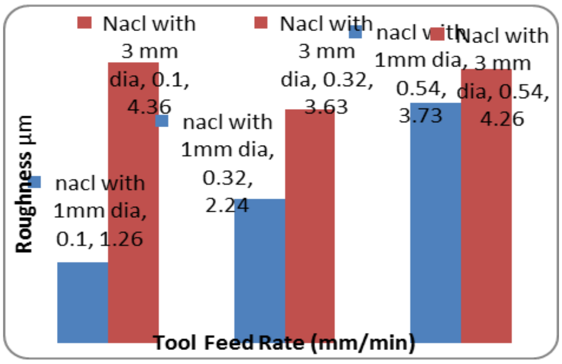
Material Removal Rate = <u>Material removed*1000</u>

(mm^3/min) ρ (7.8g/cc) * Time (3 minutes)

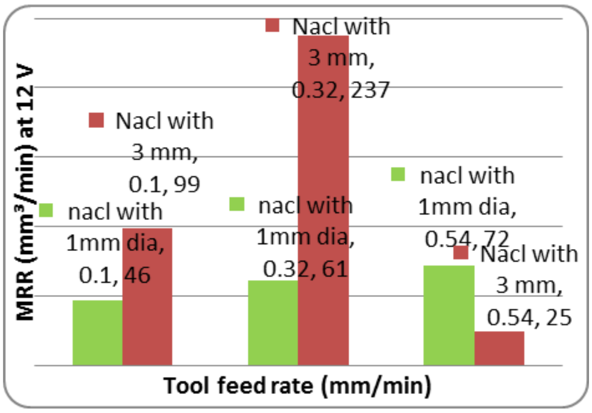
MRR vs. Tool Feed Rate, Surface Roughness



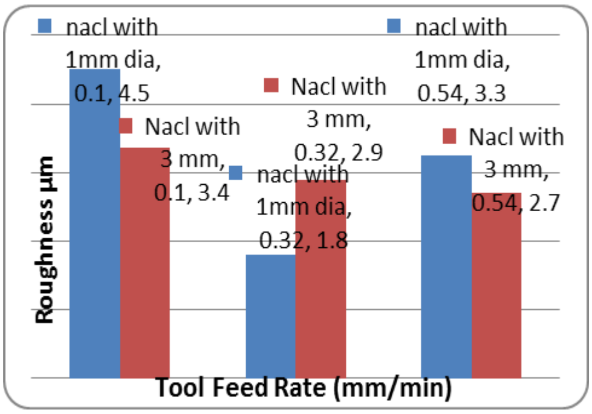
At Dis. Rate 8 lpm Graph 1
Tool Feed Rate Vs. MRR at 12V and 8 lpm



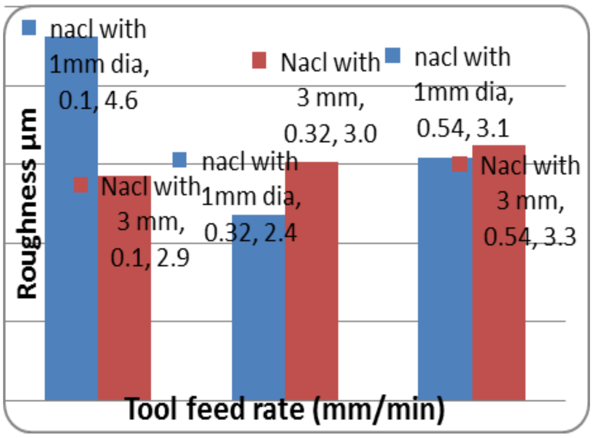
Graph1A Tool Feed Rate Vs. Roughness 12V and 8 lpm At Dis. Rate 10 lpm



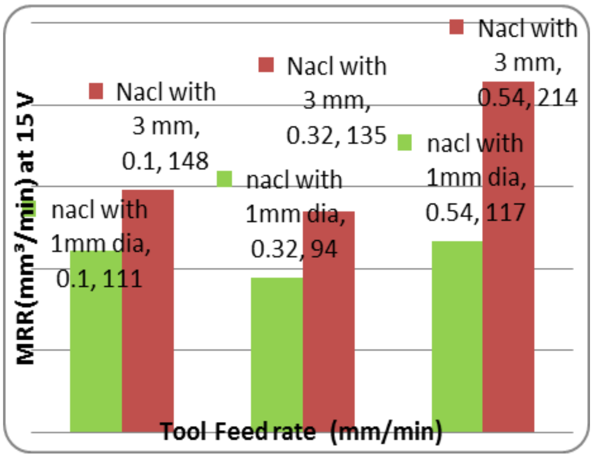
Graph2: Tool Feed Rate Vs MRR at 12V and 10 lpm At Dis. Rate 10 lpm



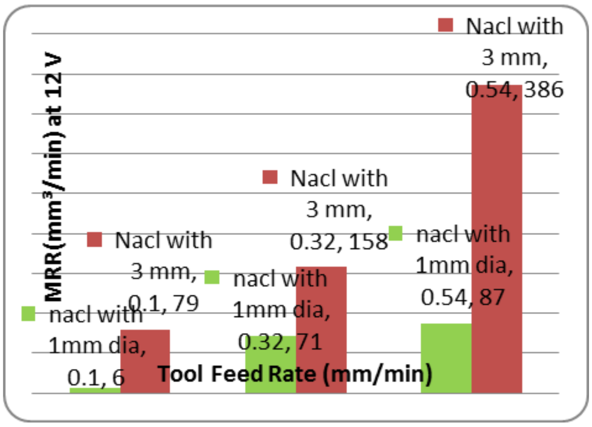
Graph3A: Tool Feed Rate Vs Roughness at 12V and 12 lpm At Dis. Rate 8 lpm



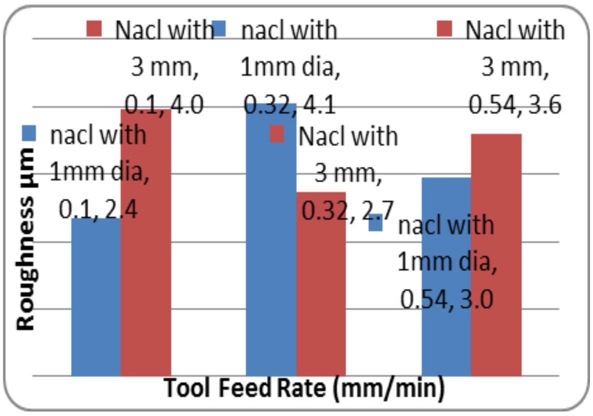
Graph2ATool Feed Rate Vs Roughness 12V and 10 lpm At Dis. Rate 12 lpm



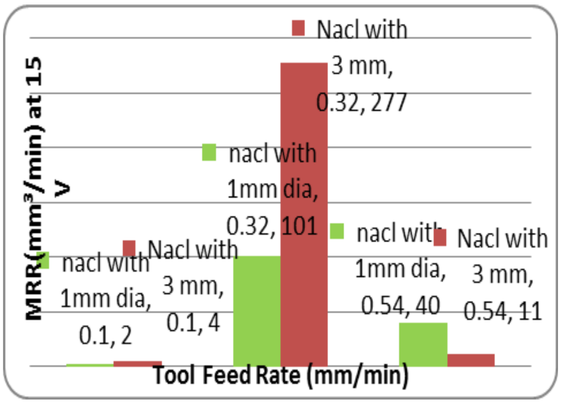
Graph4: Tool Feed Rate Vs. MRR at 15V and 8 lpm At disrate 8 lpm



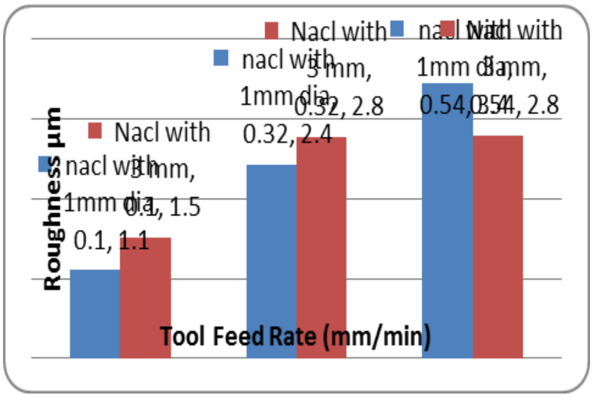
Graph3: Tool Feed Rate Vs MRR at 12V and 12 lpm At Dis. Rate 12 lpm



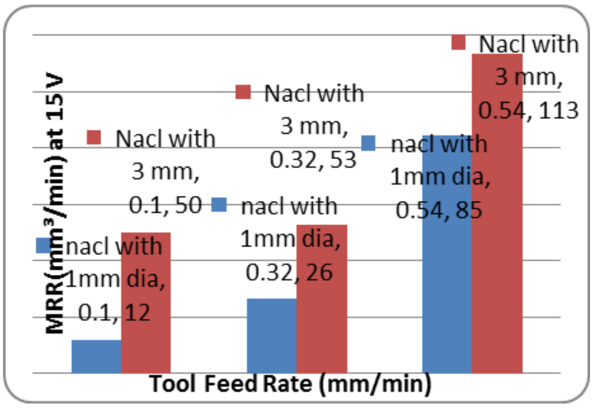
Graph4A: Tool Feed Rate Vs. Roughness at 15V and 8 lpm At Dis. Rate 10 lpm



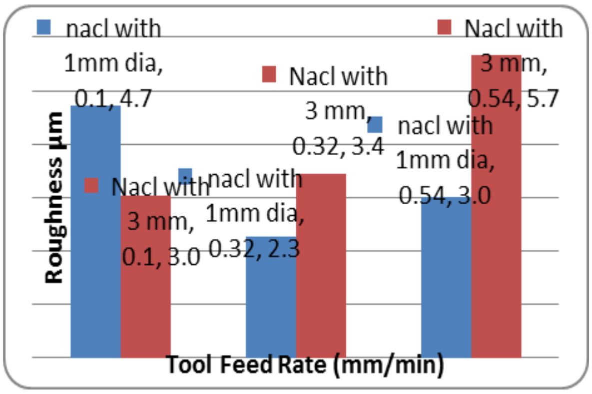
Graph5: Tool Feed Rate Vs MRR at 15V and 10 lpm At Dis. Rate 10 lpm



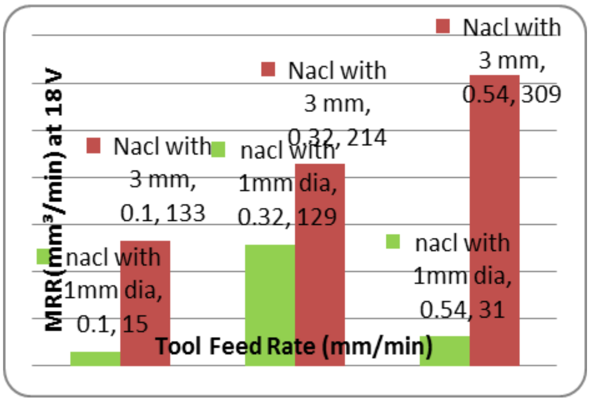
Graph5A: Tool Feed Rate Vs Roughness at 15V and 10 lpm At Dis. Rate 12 lpm



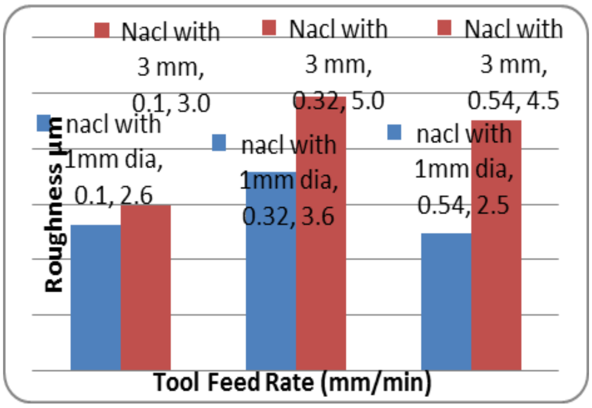
Graph6: Tool Feed Rate Vs MRR at 15V and 12 lpm At Dis. Rate 12 lpm



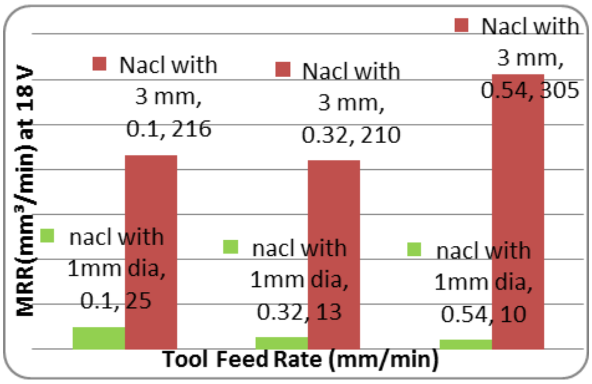
Graph6A: Tool Feed Rate Vs. Roughness at 15V and 12 lpm At Dis. Rate 8 lpm



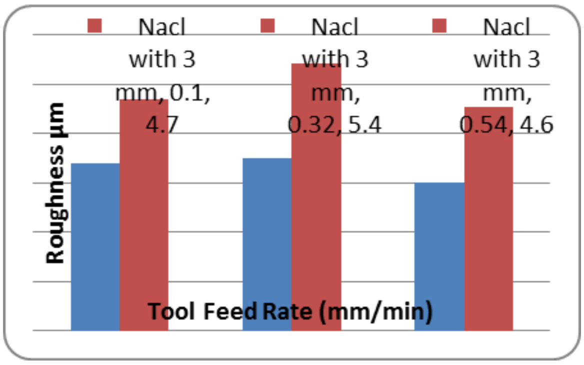
Graph7: Tool Feed Rate Vs MRR at 18V and 8 lpm At Dis. Rate 8 lpm



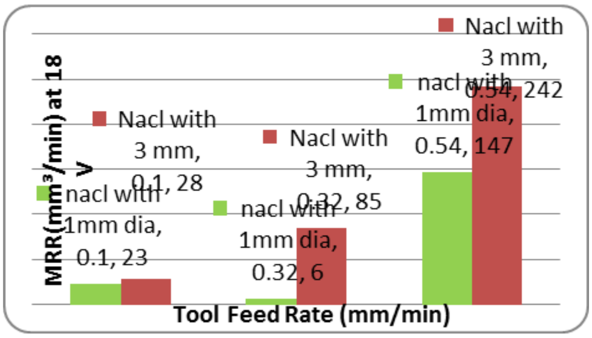
Graph7A: Tool Feed Rate Vs. Roughness at 18V and 8 lpm At Dis. Rate 10 lpm



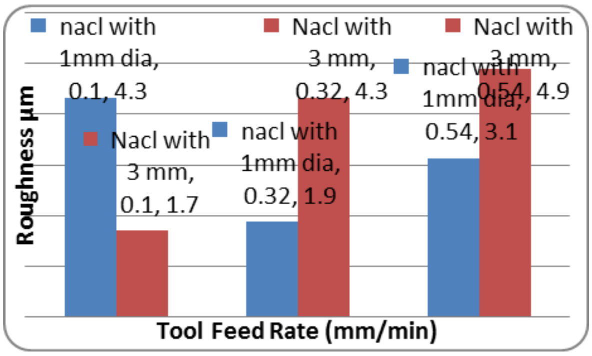
Graph8: Tool Feed Rate Vs MRR at 18V and 10 lpm At Dis. Rate 10 lpm



Graph8A: Tool Feed Rate Vs Roughness at 18V and 10 lpm At Dis. Rate 12 lpm



Graph9: Tool Feed Rate Vs MRR at 18V and 12 lpm At Dis. Rate 12 lpm



Graph9A: Tool Feed Rate Vs. Roughness at 18V and 12 lpm

VI. CONCLUSION

Electrochemical machining is the metal removal process. It is normally used for mass production and is used for working extremely hard materials or materials that are difficult to machine. This work deals with improved machining performance of HC HCr with 67 HRC by the multi-jet circular tool. By comparing the experimental results with a 3mm diameter multi-jet tool and 1mm diameter multi-jet tool. It was identified 3mm diameter multi-jet tool yields better material removal rate and minimum surface roughness (µm). These experimental works suggest that NaCl (85% of water + 15% of NaCl) gives a good result for HC HCr with 67 HRC materials.

VII. REFERENCE

[1] Lawrence.P, Computer-Aided Design for ECM Electrodes, Int. J. Mach. Tool Des. Res, 21 (1981) 379-385.

[2] E.J.Weller, Nontraditional Machining Processes, Society of Manufacturing Engineers, Publications/Marketing Division, Technology & Engineering (1984).

[3] The Electronics Industry, Journal of the Electrochemical Society, 136(6) 285c-292c

[4] Ruszaj, A, Dziedzic, J, Czekaj, J, and Krehlik, M., 1995, Electrochemical Machining with Electrode Displacement Controlled in Three Axes, Proceedings of the ISEM-11: 553-563.

[5] Prasanta Mishra, Narosa Publishing House, Non-Conventional Machining. (1997).

[6] Kozak, J., Rajurkar, K. P., Ruszaj, A., and Slawinski, R. J, 1998, Sculptured Surface Finishing, By NCElectrochemica machining with Ball-End Electrode, Advances in Technology of the Machines and Equipment, 22(1) 53-74.

[7] SK. Sorkhel, B. Bhattacharyya, C. Rudra, Investigation for controlled electrochemical machining through response surface methodology based approach, Jr. Mat. Proc.Tech, (1999) 200-207.

[8] M. Datta, D. Landolt, Fundamental aspects and applications electrochemical microfabrication, Electrochemical Acta, (2000)2535–2558.

[9] R. Kurita, H. Jabei, Z. Liu, T. Hariuchi, O. Niwa, Fabrication and electrochemical properties of an Interdigitated array electrode in a microfabricated water jet cell, Sensors and Actuators' B' Chemical, B71,(2000) 82–89.

[10] B. Bhattacharyya*, S. Mitra, A.K. Boro, Electrochemical machining: new possibilities for micromachining. Robotics and Computer Integrated Manufacturing, 18 (2002) 283–289.

[11] B, Bhattacharyya, and I.Munda, Experimental investigations on the influence of electrochemical machining parameters on machining rate and accuracy in micromachining domain," International Journal of machine tools and manufacture 43 (2003)1301 – 1310.

[12] H. Ohmori, K. Katahira, Y. Vehara, Y. Watanabe, W. Liu, Improvement of mechanical strength of micro tools by controlling surface characteristics, Annals of the CIRP 52 (1), (2003), 467–470.

[13] A.Rajeshkumar, Dr.S.Venkatesan, Review Parameters of Electrochemical Machining For 410b Stainless Steel" SSRG International Journal of Mechanical Engineering 6(1) (2019) 1-6.

[14] B.Bhattacharyya, J.Munda, and M.Malapati, Advancement in electrochemical micromachining, International Journal of Machine Tools and Manufacture, (2004) 1577- 1589.

[15] Anjali V. Kulkarni, Electrochemical machining Process, Defence Science Journal 57 (5), (2007),765-770.

[16] Dr. T.Sekar and Marappan R, Investigating the Material Removal Rate and Surface Roughness in Electrochemical Machining of High Carbon High Chromium Die Steel, Int. Journal of Engineering Research and Industrial Applications, 1(3) (2008) 121-130.

[17] Dr. T.Sekar and Marappan R, Improving Material Removal Rate of Electrochemical Machining by Using Rotating Tool, Int. Journal of Engineering Research and Industrial Applications, 1(3) (2008) 121-130.

[18] V. Sathiyamoorthy and Dr. T.Sekar, Electrochemical Machining – A Review, 1st International Conference in South Asia On, Global Manufacturing Systems & Management, (ICGMSM 2011), 1st – 3rd (2011), Coimbatore institute of technology, Coimbatore.

[19] T.sekar Dr. R.marappan, Macro to Micro approach of electrochemical machining - a review, 2nd International Conference On Resource Utilization And Intelligent Systems, Kongu Engineering College, Erode, Tamilnadu, India.