ISSN(Online) : *2456-8910*
International Journal of Innovative Research in Applied Sciences and Engineering (IJIRASE)
Volume 2, Issue 7, DOI: 10.29027/IJIRASE.v2.i7.2019, 314-318, January 2019

Experimental Study on the Effect of Magnetic Field in Electro Chemical Machining Process

[1]J.Prasanna, [2]T.Praveena, [3]M.Santhosh Kumar

[1]Assistant Professor, [2]Research Scholar, [3]PG Student
Department of Mechanical Engineering,
Anna University, Chennai, India

Abstract: Electro chemical machining is an advanced technique which has higher machining rate and capable of machining wide range of difficult-to-machining materials. This paper focuses on studying the effect of magnetic field in electro chemical machining process. In this study the experiment is conducted by applying magnetic field using permanent magnet. The work material used in the experiment is titanium grade5 and the tool material is copper. The experiment is conducted by varying the input process parameters such as Electrolyte Concentration, Pulse ON Time, Duty Factor, Peak current and the response of performance characteristics is observed. It is found that the machining rate is improved due to magneto hydrodynamic effect and overcut is reduced.

Keywords: ECM, Magnetic field.

1. Introduction

The main reason for the experimental study is increasing the machining rate and reducing the overcut while machining hole in ECM process. We have proposed a technique by introducing magnetic field using a permanent magnet based on principle of interaction between magnetic field and electric field which explained in flemming right hand rule. When the tool approach the work material both liberates electron(-ve) and metal ions(+ve) and they attract each other, now if the electrolyte is passed it leads to metal deposition. However it is electro chemical process there is a Lorentz force occurs as there is movement of charged particles from tool and work piece in between the magnetic field lead to reduce the overcut but does not have any effect in metal deposition as it is not a spark erosion process. It is justified that the machining rate can be increased by applying magnetic field by considering another magnetic effect which occurs in electrolyte is magneto hydrodynamic effect. Now we have taken the principle of Lorentz force and the magneto hydrodynamic effect as basic element to conduct the experimental study. It can be noticed that the variation of machining time under no magnetic field and under magnetic field.

2. Experiment Method

In this experimental study the experiment is carried out by machining small circula r hole on a 0.1 mm thick titanium sheet using 0.6mm diameter copper tool. The experiment method is applying the magnetic field perpendicular to the flow of electrolyte and parallel to the axis of tool movement. There are two magnets mounted across the work material vertically and parallel to each other shown in fig 1. The magnetic field is applied on both attraction and repulsion force condition which is expected to be result in significant different in machining performance. Each experiment is done by placing the work material between the gap of two oppositely faced magnets and electrolyte is made to flow on it then the machining is done by let the tool on the surface of work material under No Magnetic Field, Attraction and Repulsion condition. The machining time for each experiment under each condition is noticed and the overcut of the hole is calculated by measuring actual holes diameter and tool diameter.

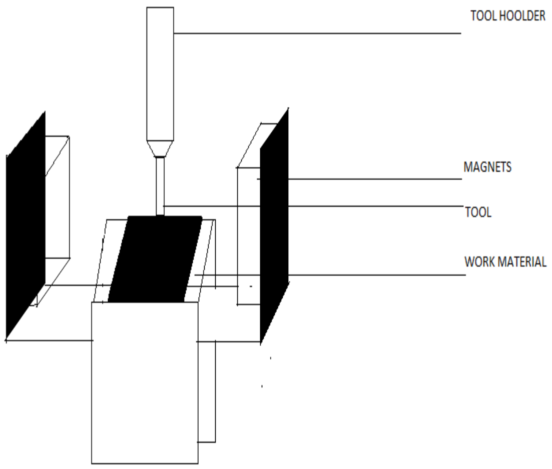


Fig 1 Schematic Representation of Fixture of Magnet and Work Material

ISSN(Online) : 2456-8910
International Journal of Innovative Research in Applied Sciences and Engineering (IJIRASE)
Volume 2, Issue 7, DOI: 10.29027/IJIRASE.v2.i7.2019, 314-322, January 2019

2.1 Material used:

Work material: Titanium grade 5 (Ti-6Al-4V)
Tool material : Copper
Magnet : Neodymium magnet

2.2 *Electrolyte used:*

The electrolyte used in this experimental study is solution of sodium chloride (NaCl) where Na is positive and cl is negative. The electrolyte solution is made by dissolving the NaCl in water.

2.3 Process Parameters:

Concentration of Electrolyte: 15 g, 22.5 g and 30 g
Peak current voltage (IP) : 1.2 A – 1.5 A
Pulse on time : 300 µs – 500 µs
Duty factor : 0.5 – 0.7

2.4 Design of Experiments

Taguchi has envisaged a new method of conducting the design of experiments which are based on well-defined guidelines. This method uses a special set of arrays called orthogonal arrays. The standard arrays stipulates the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in choosing the level combinations of the input design variables for each experiment. The L9 orthogonal array is meant for understanding the effect of 4 independent factors each having 3 factor level values. This array assumes that there is no interaction between any two factors. While in many cases, no interaction model assumption is valid, there are some cases where there is a clear evidence of interaction.

2.5 Performance Characteristics and Its Calculation

The performance characteristics are the measurable variable from which the performance of machining can be analysed.

Machining Rate:

Machining rate is defined as the speed at which the work moves with respect to the tool.
The machining rate is calculated by the following formula,

Machining rate = (Thickness of Sheet/ Machining Time) mm/ min

Overcut :

Overcut is the gap between electrode and mechanical hole. To measure the overcut, always the maximum hole diameter is taken.
It can be calculated by

Overcut = Maximum Hole Diameter – Tool Diameter (mm)

3. Results and Discussion

3.1 Experiment Results

The experimentation has done in various machining conditions by varying the process parameters concentration of electrolyte, peak current, pulse on time, duty factor using L9 orthogonal array.
Each experiment has conducted under mainly three conditions.

(i) Experiment without magnetic field.

(ii) Experiment with attractive magnetic field.
(iii) Experiment with repulsive magnetic field.

Table 1 Experimentation without Applying Magnetic Field

Ex. NO	Process Parameters				Performance Characteristics	
	Concentration of Electrolyte (g/l)	IP Voltage (A)	Pulse On Time Ton (µs)	Duty Factor	Over Cut (mm)	Machining Rate (mm/min)
1.	15	1.2	300	0.5	0.42	0.0448
2.	15	1.35	400	0.6	0.25	0.0882
3.	15	1.5	500	0.7	0.30	0.0625

ISSN(Online) : 2456-8910
International Journal of Innovative Research in Applied Sciences and Engineering (IJIRASE)
Volume 2, Issue 7, DOI: 10.29027/IJIRASE.v2.i7.2019, 314-318, January 2019

Table 2 Experimentation under Attractive Magnetic Field

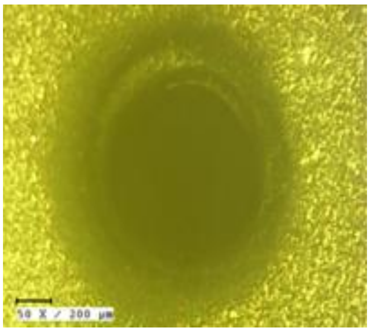
Ex. NO	Process Parameters				Performance Characteristics	
	Concentration of Electrolyte (g/l)	IP Voltage (A)	Pulse On Time Ton (µs)	Duty Factor	Over Cut (mm)	Machining Rate (mm/min)
1.	15	1.2	300	0.5	0.27	0.0566
2.	15	1.35	400	0.6	0.31	0.1034
3.	15	1.5	500	0.7	0.34	0.0968

Table 3 Experimentation under Repulsive Magnetic Field

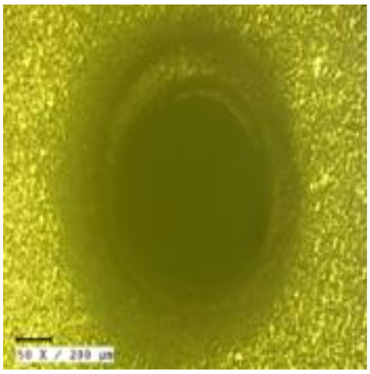
S.No	Process Parameters				Performance Characteristics	
	Concentration of Electrolyte (g/l)	Ip Voltage (A)	Pulse On Time Ton (µs)	Duty Factor	Over Cut (mm)	Cutting Speed (mm/min)
1.	15	1.2	300	0.5	0.23	0.0714
2.	15	1.35	400	0.6	0.31	0.1224
3.	15	1.5	500	0.7	0.22	0.1053

3.1.1 Microstructural View of Machined Holes

Magnification: 50X/200µs for all the holes

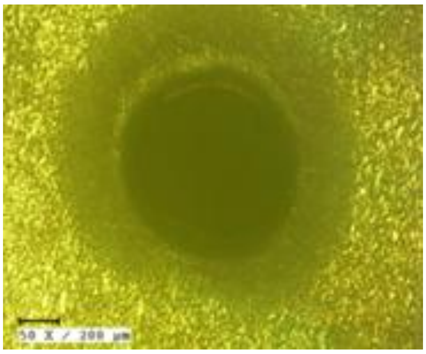


a) Without magnetic field



b) Attraction

ISSN(Online) : 2456-8910
International Journal of Innovative Research in Applied Sciences and Engineering (IJIRASE)
Volume 2, Issue 7, DOI: 10.29027/IJIRASE.v2.i7.2019, 314-322, January 2019



c) Repulsion

Fig 2 Microscopic view of machined holes under experimental condition 3

3.2 Discussion

According to the three conditions that the performance characteristics of ECM process for each experiment is compared to analyse the effect of magnetic field in each experiment. The comparative analysis that helps to find the experimental condition in which the effect of magnetic field results in improved performance characteristics. From the above table it is found that cutting speed increased under the effect of magnetic field in all experiments. Especially, machining rate in repulsive magnetic field is greater than attractive magnetic field. In every experiment the cutting speed is greater in repulsive condition. As the repulsion condition result in increased machining rate than other two condition it is taken maximum value for calculating the percentage increase in cutting speed, while the machining rate without magnetic field is taken as minimum value. Overcut is the gap between electrode and mechanical hole. To measure the overcut, always the maximum hole diameter is taken. From the above experiment there is different in overcut between attraction and repulsion condition. In some experiments there is better circularity and reduced overcut in c attraction condition and in the remaining experiment repulsion gives better circularity and reduced overcut. However the overcut is reduced during applying magnetic field than without magnetic field. By comparing all the experiment, it is inferred that the experiment seven result in increased cutting speed and reduced overcut when compared to the other experimental condition.

3..2.1 Average of Machining Rate and Overcut

Table 4 Average of Machining Rate

	Without Magnetic Field	Attraction	Repulsion	Percentage Increased %
Machining Rate	0.0617	0.0754	0.0952	35.21

3.2.1 Average of Machining Rate and Overcut

Table 4 Average of Machining Rate

	Without Magnetic Field	Attraction	Repulsion	Percentage Increased %
Machining Rate	0.0617	0.0754	0.0952	35.21

Table 5 Average of Overcut

	Without Magnetic Field	Attraction	Repulsion	Percentage Reduction %
OVERCUT	0.31	0.275	0.23	25.8

It is proved that the machining rate is increased and overcut is reduced in both attraction and repulsion from the average value. Especially in repulsion the overcut better than other two conditions and cutting speed also increased.

3.2.2 Justification of effect of magnetic field

In normal process it known that the electrolyte act as a conducting medium contains ions which are neutralized initially. But when the voltage is applied the ion in the electrolyte is separated in to anions and cation. When the tool(cathode) approaches the work material(anode) the anode liberates the positive metal ions and cathode liberates negative electrons. Now the anions conduct the electron to the anode and the cation conducts metal ions to the cathode lead to metal removal. Now in this experimental study it is justified that there is a significant effect due to applying the magnetic field using neodymium permanent magnet. The magnetic field is applied across the charged work material. When the charged electrolyte flow through the magnetic field there is a current induced in the electrolyte which conducts positive ions from work material and electrons from tool. As the speed of movement of ions increased in the electrolyte, the metal ions from the titanium deposited to the tool is increased due to faster movement anion and cations. This effect is called as magneto hydrodynamic effect.

4. Conclusion

It is proved that there is increased machining rate machining rate in ECM process due to magneto hydrodynamic effect when applying magnetic field using neodymium magnet. It is found that the machining rate and metal deposition is always increased in repulsion of magnetic field than attraction. The machining rate improvement can be written as Repulsion > attraction > without magnetic field. From all the experiments we have considered that 7th experiment is better than other parameter setting in which both the machining rate and overcut has achieved its expected level. It is inferred that the effect of magnetic field is obvious and the machining has achieved the improved performance to the expected level.

5. References

[1] Andreas Bund, Adriana Ispas and Gerd Mutschke 2007, Magnetic field effects on electrochemical metal depositions Sci. Technol. Adv. Mater. 9 (2008) 024208 (6pp).

[2] C. Bradley, J. Samuel 2017. Magneto hydrodynamic electrolyte flow within an inter-electrode gap driven by a sinusoidal electric field and constant magnetic field.

[3] Chen, Xuezhen, Xu, Zhengyang, Zhu, Dong, Fang, Zhongdong, Zhu, Di. Experimental research on electrochemical machining of titanium alloy Ti60 for a blisk.

[4] F. Klocke, M. Zeis, A. Klink, D. Veselovac. Experimental research on the electrochemical machining of modern titanium- and nickel-based alloys for aero engine components, Procedia CIRP 6 (2013) 368 –372. Int. J. Electrochem. Sci., 10 (2015) 4812 – 4819.

[5] K.P. Rajurkara, M. M. Sundaram, A. P. Malshe. Review of Electrochemical and Electro-discharge Machining, Procedia CIRP 6 (2013) 13 – 26.

[6] L. Tang & W. M. Gan 2014. Experiment and simulation study on concentrated magnetic field-assisted ECM S-03 special stainless steel complex cavity, Int J Adv Manuf Technol (2014) 72:685–692.

[7] Li Long & M. A. Baoji 2017. Effect of magnetic field on anodic dissolution in electrochemical machining, Int J Adv Manuf Technol (2018) 94:1177–1187.

[8] S.K. Farida, M. M. Billah, M. M. Rahman, Uddin Md. Sharif. Numerical study of fluid flow on magneto hydrodynamic mixed convection in a lid driven cavity having a heated circular hollow cylinder, Procedia Engineering 56 (2013) 474 – 479.

[9] Yundan Yu1, Zhenlun Song, Hongliang Ge, Guoying Wei, Li Jiang 2015 Effects of Magnetic Fields on the Electro deposition Process of Cobalt,

[10] Zhijian Fan∗, Tiancheng Wang, Ling Zhong 2003. The mechanism of improving machining accuracy of ECM by magnetic field, Journal of Materials Processing Technology 149 (2004) 409–413.