Study the Influence of electrolytes in Electro Chemical Machining

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ABSTRACT

Electrochemical machining has established itself as one of the major alternatives to conventional methods for machining hard materials and complex contours without the residual stresses and tool wear. Studies on Material removal rate (MRR) are of utmost importance in ECM, since it is one of the determining factors in the process decisions. This paper deals that to investigate the improvement in the material removal rate of electrochemical machining. Experimental MRR has been calculated for different electrolytes condition on aluminum and stainless steel. The experimental results indicate that by using sea water as an electrolyte in electrochemical machining on aluminum alloy and steel alloy gives better MRR.

1. INTRODUCTION

Electrochemical Machining ECM is a process based on the controlled anodic dissolution process of the work piece anode, with the tool as the cathode, in an electrolytic solution. The electrolyte flows between the electrodes and carries away the dissolved metal. The main advantages of ECM are:

1. Machining does not depend on the hardness of the metal;
2. Complicated shapes can be machined on hard surfaces;
3. There is no tool wear;
4. It is environmental friendly.

When this process is applied to the micromachining range for manufacturing of micro components or features, it is referred as electrochemical micromachining EMM.

2. PRINCIPLE OF ECM

Electrochemical machining is developed on the principle of Faradays and Ohm. In this process, an electrolyte cell is formed by the anode (work piece) and the cathode (tool) in the midst of a following electrolyte. The metal is removed by the controlled dissolution of the anode according
to the well known Faradays law of electrolysis. When the electrode are connected to about 24 v

Electric supply source, flow of current in the electrolyte is established due to positively charged ion being attracted towards cathode and vice-versa. Due to electrolysis process at cathode hydroxyl ion are released which combine with the metal ions of anode to form insoluble metal hydroxide. Thus the metal is removed in the form of sludge and precipitated in electrolytic cell. This process continues till the tool has produced its shape in the work piece.

3. ELECTROLYSIS

Electrolysis is the name given to the chemical process which occurs, for example, when an electric current is passed between two conductors dipped into a liquid solution.

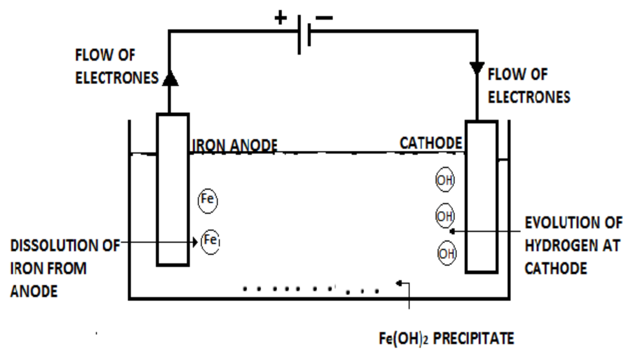

Fig 1. Electrolysis with NaCl

Reactions that occur during the electrolysis of iron (Figure 1) are as follows. The anodic reaction is ionizing of iron:

$$Fe \Longrightarrow Fe^{2+}(aq) + 2e^-$$

At the cathode, the reaction is likely to be the generation of hydrogen gas and the production of hydroxyl ions:

$$H_2O + 2e^- \Longrightarrow H_2 + 2OH$$

The net reaction is thus: $Fe + 2H_2O \Longrightarrow Fe(OH)_2(s) + H_2$

The ferrous hydroxide may react to form ferric hydroxide:

$$4Fe(OH)_2 + 2H_2O + O_2 \Longrightarrow 4Fe(OH)_3$$

The system of electrodes and electrolyte is referred to as the electrolytic cell, whilst the chemical reactions which occur at the electrodes are called the anodic or cathodic reactions or processes.

3. MECHANISM OF ELECTROLYSIS PROCESS

Electrolytes are different from metallic conductors of electricity in that the current is carried not by electrons but by atoms, or group of atoms, which have either lost or gained electrons, thus acquiring either positive or negative charges. Such atoms are called ions. Ions which carry positive charges move through the electrolyte in the direction of the positive current that is, toward the cathode and are called cations. Similarly, the negatively charged ions travel toward the anode and are called anions. The movement of the ions is accompanied by the flow of electrons, in the opposite sense to the positive current in the electrolyte, outside the cell, as shown in Figure 1 and both reactions are a consequence of the applied potential difference that is voltage from the electric source.[8]

4. EQUIPMENT

The electrochemical machining system has the following modules:

- Power supply
- Electrolyte filtration and delivery system
- Tool feed system
- Working tank

Figure 2 shows the schematic set up of ECM [1] in which two electrodes are placed at a distance of about 0.5 to 1mm & immersed in an electrolyte, which is a solution of sodium chloride [8]. When an electrical potential of about 24V is applied between the electrodes, the ions existing in the electrodes migrate toward the electrodes. Positively charged ions are attracted towards the cathode & negatively charged towards the anode. This initiates the flow of current in the electrolyte. This process continues and tool reproduces its shape in the work piece (anode). The high current densities promote rapid generation of metal hydroxides and gas bubble in the small spacing between the electrodes.

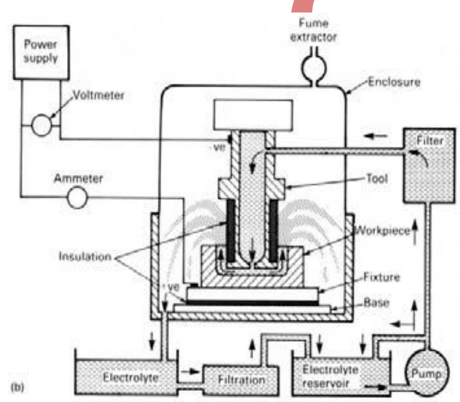

Fig.2 shows the schematic set up of ECM

5. PROCESS PARAMETERS IN ECM

Following are the some parameters which govern the ECM.

5.1 Voltage

The nature of applied power supply is of two types: DC (full wave rectified) and pulse DC. A full wave rectified DC supplies continuous voltage and a pulse generator is used to supply pulses of voltage with specific on-time and off-time. In ECM, the use of pulse voltage has the following advantages:[7] • The waste sludge can be removed during the off-time, as the formation of the sludge in the narrow gap might lead to clogging and deposition on the tool, which will have an adverse effect on the machining process.

• It prevents the electrolyte from reaching high temperatures. The use of sufficient off-time allows it to cool down to normal temperature.

• The gap checking and tool repositioning can also be conducted during these pulse pauses to establish a given gap size, before the arrival of the next pulse, leading to a significant reduction in the indeterminacy of the gap and, hence, of the shaping accuracy.

• The use of pulsed voltage also improves the surface finish criteria of EMM.

5.2 Inter-electrode gap(IEG)

The gap between the tool (cathode) and the work piece (anode) is important for metal removal in ECM processes.[6] It plays a major role for accuracy in shape generation.

5.3 Electrolyte and its concentration

ECM electrolyte is generally classified into two categories:
a) Passivity electrolyte containing oxidizing anions e.g. sodium nitrate and sodium chlorate, etc.
b) Non-passivity electrolyte containing relatively

Aggressive anions such as sodium chloride. Passivity electrolytes are known to give better machining precision. This is due to their ability to form oxide films and evolve oxygen in the stray current region. Most of the investigation researchers recommended NaNO3 and NaCl solution with different concentration for electrochemical machining (ECM). The pH value of the electrolyte solution is chosen to ensure good dissolution of the work piece material during the process without the tool being attacked. It is usual to work with natural NaCl electrolyte solution. The metal removal rate (MRR) increases with increase in electrolyte concentration.

6. EXPERIMENTATION WORK

Experimental runs are taken on ECM setup by various electrolytes and keeping IEG, voltages are constant. Actual MRR is calculated for various readings

6.1. Experimental setup

Fig 3 shows a photograph of the experimental set of ECM on which the said experimentation is carried out.

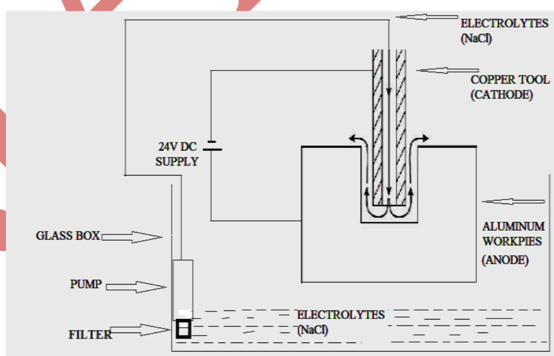

Fig 3. Experimental setup of ECM

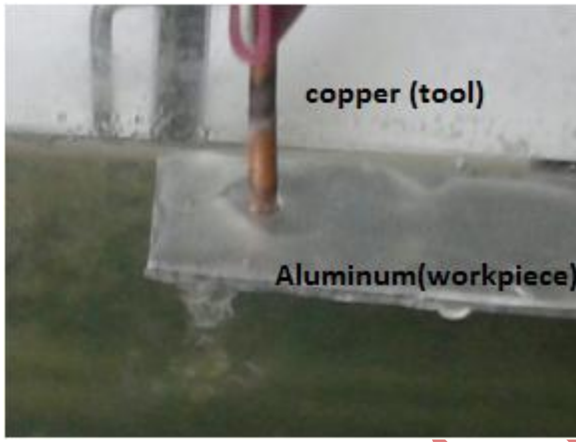

Fig.4.Electrochemical Machining Process.

Fig 5.Aluminum Work piece after machining

Fig 6.Stainless steel work piece after machining

7. PROCESS PARAMETERS

• **Tool**: copper (2mm diameter)

•**Types of Electrolytes:** NaCl, KAlSO4, Na2NO3, Na_2SO_4, K_2S0_4, K_2NO_3 (35gm/liter), sea water

• **Flow rate:** 10 Ltr/hr

• **Work piece**: Stainless steel EN Series 58A (AISI 302B) And Aluminum 6063.

7.1 Components of alloy

Table No 1 shows the various components of alloy
Stainless steel EN Series 58A (AISI No 302B)

Table7.1 various components of alloy

Element	Composition (%)	Density (g/cm3)	Atomic weight	Valency
Carbon C	1.18	2.26	12.011	2
Manganese Mn	1.43	7.43	54.938	2
Silicon Si	0.44	2.33	28.086	4

Chromium Cr	18.65	7.19	51.996	2
Nickel Ni	8.20	8.90	58.693	3
Iron Fe	69.85	7.86	55.845	2

Table7.2. shows the various components of alloy Aluminum 304.

Element	**Component (%)**	**Density (g/cm^3)**	**Atomic Weight**	**Valency**
Silicon Si	.2	2.3290	28.085	4
Iron Fe	.35	7.874	55.845	2
Copper Cu	.10	8.96	63.546	2
manganese Mn	.10	7.21	54.93804	2
magnesium Mg	.45	1.738	24.305	2
Chromium Cr	.10	7.19	51.9961	2
Titanium Ti	.10	4.506	47.867	
zinc Zn	.10	7.14	65.38	2
aluminum Al	98.5	2.7	26.98153	3

Table No 3 shows the readings and calculated MRR for various electrolytes on aluminum while voltage, current and IEG were kept constant during all readings. MRR is given in g/sec.Table7.3. shows the readings and calculated MRR for various electrolytes on aluminum

7.3 Observation table for different electrolyte

Sr no	**Electrolyte**	**Initial weight(g)**	**Final weight(g)**	**Time (sec)**	**MRR (g/sec)**
1	$Kalso_4$	13.2409	13.2332	20	3.85e-4

2	Kno_3	13.243	13.2055	20	1.873e-3
3	Na_2SO_4	13.6793	13.6681	20	5.6e-4
4	K_2SO_4	14.2361	14.2252	20	5.43e-4
5	NaCl	14.4769	14.4140	20	3.145e-3
6	$Nano_3$	12.4438	12.3370	20	5.34e-3
7	Sea water	13.2183	13.0466	20	8.583e-3

Table No 4 shows the readings and calculated MRR for various electrolytes on stainless steel while voltage, current and IEG were kept constant during all readings. MRR is given in g/sec.

Table7.4.Shows the readings and calculated MRR for various electrolytes on stainless steel

Sr no	Electrolyte	Initial weight(g)	Final weight(g)	Time (sec)	MRR (g/sec)
1	$Kalso_4$	25.4821	25.4664	20	7.85e-4
2	Kno_3	23.8345	23.8046	20	1.495e-3
3	Na_2SO_4	21.5112	21.5081	20	1.55e-3
4	K_2SO_4	28.4283	28.3956	20	1.634e-3
5	NaCl	21.9213	21.7265	20	8.675e-3
6	$Nano_3$	27.0121	26.9825	20	1.455e-3
7	Sea water	24.5421	24.2464	20	.014785

8. CONCLUSION

The experimentation work consists of study the influence of electrolytes in electrochemical machining. Some of the other process parameter such as machining voltage and inter electrode gap (IEG), tool diameter etc kept as constant. The actual and theoretical material removal rates were calculated and also find the percentage of error for each condition. The seawater gives the appreciable amount of MRR.

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