Improving The MRR of Electro-Chemical Machining Process Through Heating The Electrode Tool Holder

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Abstract- *Electro chemical micro machining(EMM) is a non-conventional machining process which successfully demonstrated micro holes on composite materials. Already MRR(Material Removal Rate) of EMM process gets improved by following parameters Voltage, Duty cycle, Electrolytic Concentration & Frequency. This paper revealed that the temperature of the electrode holder also influences the MRR of this machining process. Aluminium composite plates are used for machining and analyzing the comparison between with and without heating of electrode holder machining was done.*

Keywords- EMM, Electrode Holder, Heat, Temperature, MRR, Overcut

I. INTRODUCTION

Current engineering applications require materials that are stronger, lighter and less expensive. A good example is the current interest in the development of materials that have good strength to weight ratio suitable for automobile applications where fuel economy with improved engine performance are becoming more critical. In-service performance demands for many modern engineering systems require materials with broad spectrum of properties.Quite difficult to meet using monolithic material systems. Metal matrix composites (MMCs) have been noted to offer such tailored property combinations required in a wide range of engineering applications. MMCs are fast replacing conventional metallic alloys in so many applications as their use have been extended from predominantly aerospace and automobile to defence, marine and sports.

The common metallic alloys utilized are alloys of light metals (Al, Mg and Ti) however, other metallic alloys like zinc (Zn), copper (Cu) and stainless steel have been used. Aluminium remains the most utilized metallic alloy as matrix material in the development of MMCs and the reasons for this has been reported. However, high cost and limited supply of conventional ceramic reinforcing materials especially in developing countries has remain a major problem associated with the development of discontinuously reinforced aluminium matrix composites. Research efforts put in place to resolve these problems are mostly channeled towards selecting the right choice of reinforcing materials. This is an indication that the reinforcing materials play significant role in determining the overall performance of the composites. GGBS is used as a reinforcement material with Al6061. This is aimed at providing solution to problems posed by high cost and limited availability of conventional ceramic reinforcements. Industrial wastes and agro waste derivatives are some of the alternative reinforcing materials that have been investigated. The results obtained from the investigations carried out on these alternative reinforcements have been promising as they show significant improvement in the properties of the composites developed over the unreinforced alloy. Stir casting technique has remained the most investigated technique for fabricating AMCs owing to its simplicity, flexibility and commercial. Aluminium is casted with the various compositions such as 3%, 6%, 9% and 12%.Stir processing as a novel technique for developing metal matrix composites (MMCs). This has become necessary because metal matrix composites developed via stir casting are often reported to have increased strength and stiffness at the expense of ductility and toughness.

Conventional machining techniques are used to produce micro-slots in complex surfaces and micro-holes in large numbers, sometimes in a single work piece, especially in electronic industries. The problems generally faced in conventional machining techniques are tool wear, rigidity problem of the tool, and heat generation at the tool–work piece interface.Non-traditional machining processes overcome above cited problems due to its versatility and controlled parameters. The non-conventional machining process such chemical machining and electrochemical machining are thermal free processes, but chemical machining cannot be controlled properly in this micromachining domain. Electrochemical micro-machining(EMM) with heating the electrode holder appears to be a very promising micromachining technology due to its advantages that include high MRR, rapid machining time and environmentally acceptable, it also permits machining of chemically resistant materials like titanium, copper alloys, super alloys and stainless steel, which are widely used in biomedical and electronic applications.Minitab and Matlab are statistical and mathematical analysis packages that allow the manipulation and visualization of data. They are similar programs, and many of their features overlap—both can perform the basic range of statistical procedures common to all such programs.

II. METHODOLOGY

A. Design and dimensions

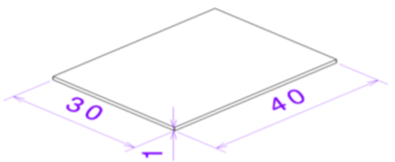

Fig.1. Dimension of Work piece

Work piece have been machined for 40*30*1 dimension
All Dimensions are in mm.

Components Required

B.Heated Electrode setup of ECMM

The machining set-up of micro ECM consists of various sub components as shown in fig.32.1.1 They are

- ✓ Work holding platform
- ✓ Tool feeding device
- ✓ Control system
- ✓ Power supply system
- ✓ Heated Electrode System
- ✓

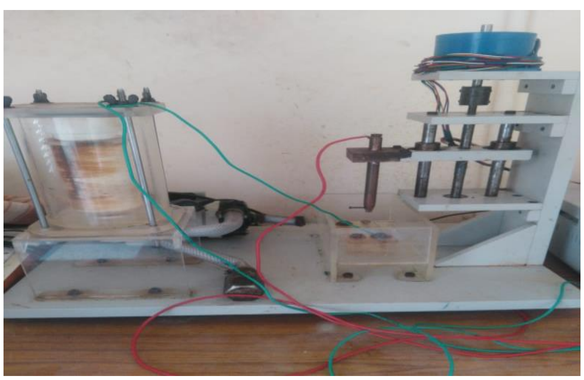

Fig.2.Heated Electrode setup of ECMM

C. Stir casting

Liquid state fabrication of Metal Matrix Composites involves incorporation of dispersed phase into a molten matrix metal, followed by its Solidification. In order to provide high level of mechanical properties of the composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained. Wetting improvement may be achieved by coating the dispersed phase particles (fibers). Proper coating not only reduces interfacial

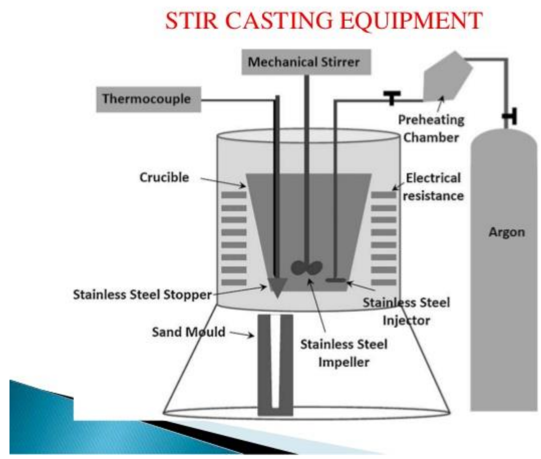

Fig.3.Stir casting equipment

1. There are local clouds (clusters) of the dispersed particles (fibers);
2. There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.
3. The technology is relatively simple and low cost.
4. Distribution of dispersed phase may be improved if the matrix is in semi-solid condition. The method using stirring metal composite materials in semi-solid state is called rheocasting. High viscosity of the semi-solid matrix material enables better mixing of the dispersed phase.

III. MATERIALS REQUIRED

A. Al matrix composite

Metal Matrix Composites are composed of a metallic matrix (Al,Mg,Fe,Cuetc) and a dispersed ceramic (oxide, carbides) or metallic phase(Pb,Mo,Wetc).

Ceramic reinforcement may be silicon carbide, boron, alumina, silicon, boron nitride etc.Whereas Metallic Reinforcement may be tungsten, beryllium etc.

MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. From a material point of view, when compared to polymer matrix composites.

*I. Aluminium 6061-t6:*T6 temper 6061 has an ultimate tensile strength of at least 290 MPa (42,000 psi) and yield strength of at least 240 MPa (35,000 psi). More typical values are 310 MPa and 270 MPa, respectively. In thicknesses of 6.35 mm (0.250 in) or less, it has elongation of 8% or more; in thicker sections, it has elongation of 10%. T651 temper has similar mechanical properties. The typical value for thermal conductivity for 6061-T6 at 25 °C (77 °F) is around 152 W/m K. A material data sheet defines the fatigue limit under cyclic load as 97 MPa for 500,000,000 completely reversed cycles using a standard RR Moore test machine and specimen. Note that aluminium does not exhibit

II.6061-T6 is used for:

- Bicycle frames and components.
- The pioneer plaque was made of this alloy.
- The secondary chambers and baffle systems in firearm sound suppressors (primarily pistol suppressors for reduced weight and improved mechanical functionality), while the primary expansion chambers usually require 17-4PH or 303 stainless steel or titanium.
- The upper and lower receivers of many non mil-spec ar-15 rifle variants.
- Many aluminium docks and gangways are constructed with 6061-t6 extrusions, and welded into place.

III. Properties of aluminium 6061 – t6

TABLE.1.PHYSICAL PROPERTIES

Property	Metric Value
Density	2.7 g/cc

TABLE.2. THERMAL PROPERTIES

Property	Metric value
Specific Heat Capacity	0.896 J/g-°C
Thermal Conductivity	167 W/m-K
Melting Point	582 - 652 °C
Solidus	582 °C
Liquidus	652 °C

B. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

I. Ground Granulated Blast Furnace Slag

The MgO and Al2O3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition. The latter being mostly expressed as the binder compressive strength.

The glass content of slags suitable for blending with Portland cement typically varies between 90-100% and depends on the cooling method and the temperature at which cooling is initiated. Increased amounts of network-modifiers lead to higher degrees of network depolymerization and reactivity.

Common crystalline constituents of blast-furnace slags are merwinite and melilite. Other minor components which can form during progressive crystallization are belite, monticellite, rankinite, wollastonite and forsterite. Minor amounts of reduced sulphur are commonly encountered as oldhamite.

IV. FABRICATION

A.Materials

Aluminium 6061 with Ground Granulated Blast Furnace Slag (GGBS) is used as reinforced material. It is used as the preparation for composite specimens. Compositions are as follows:

Fig.4.Ground Granulated Blast Furnace Slag(GGBS)

TABLE.3. COMPOSITION OF ALUMINIUM AND GGBS IN PERCENTAGE

S.No	Material in %	Reinforcement Material in wt.%
1	Al6061 - 97%	3%
2	Al6061 - 94%	6%
3	Al6061 - 91%	9%
4	Al6061 - 88%	12%

The steps includes:

a. Raw material casting
b. Adding reinforcement material
c. Stirring process
d. Discharge into mold cavity as per the dimensions
e. Solidify.

Stir casting is convenient and commercial method for casting, it is relatively low cost liquid processing method to fabricate MMCs. This method is simple, flexible and attractive as it also allows fabricating very large size components.

Fig.5.Stir Casting Process

Aluminium alloys were first cut into smaller pieces then 1 kg of Al alloy is placed in the crucible at temperature. The molten metal matrix is stirred for the first two minutes to create a vortex before adding in the preheated particulates. The reinforced particles are preheated in the furnace to remove all the moisture on the particles surface for better binding results. Preheated reinforcement particles were then added into the molten Al alloy. Then stirring is done continuously for avoiding bubbles and impurities on surface that causes porosity on the material. Subsequently the composite is poured (by bottom pouring casting) into a mould for obtaining the required shape of an Al MMC and then allowed into solidification.

B.Machining

Fig.6.EMM Micro holes on plate.

Micro holes are produced on aluminium plate for different temperature.

IV. RESULTS AND DISCUSSIONS

TABLE.4.EFFECT OF ELECTRODE HOLDER TEMPERATURE ON MRR AND OVERCUT.

Ex.No	Temperature (^{0}c)	MRR (gm/min)	Overcut (µm)
1	20	0.075	23
2	30	0.092	35
3	40	0.116	73
4	50	0.122	144
5	60	0.129	173

A.Effect of electrode holder temperature on MRR and Overcut.

when the temperature increases simultaneously material removal rate and overcut also increases.By scientifically analyzing, it unveil that the heating the electrode tool holder increases kinematic acceleration of electrons in the tool. Simultaneously, it removes material from anode in a maximum way. Overcut takes place because dirt formed on a metal surface and unwanted bubble created around tool.

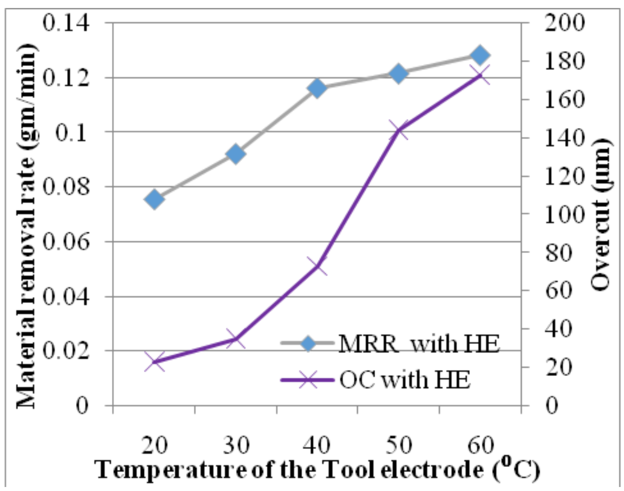

Fig.7.Effect of electrode holder temperature on MRR and Overcut.

The graphgive additional knowledge about temperature effect on MRR and Overcut.

B.APPLICATIONS

The key applications in different sectors demanding developments in micromachining are

- Cooling holes in gas-micro turbines,
- Fuel injection nozzles,
- Components of wrist watches,
- Biochips,
- Opto-electronic components,
- Nuclear reactor components,
- Inkjet nozzles,
- Printed circuit boards,
- Microfluidic channels,
- Surgical micro-tools,
- Micro-dies, implants, etc.
- In micromachining domain, the application of mechanical micromachining processes such as micro-milling, micro-turning etc.

V. CONCLUSION

In the current work, an existing EMM setup has been modified with electrode comprising of heating coil, thermostat and power supply.Byexperiments,it is concluded that Heating sthe electrode holder improves the machining rate by 88.37%, reduces the ROC by 37.03%.This new methodology can further be exploited for machining of various other geometric features with high dimensional accuracy on aluminium composite to analyze the effects of various other machining parameters.

REFERENCES

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

[2] Bhattacharyya. B, Munda. J and Malapati. M (2004) Advancement in electrochemical micro-machining, International Journal of Machine Tools & Manufacture 44, 1577–1589.

[3] Bhattacharyya. B, Rajurkar K.P., D.Zhu, J.A. McGeough, J. Kozak and A. De SilvaNew Developments in Electrochemical Machining, Research paper.

[4] Bhattacharyya. B, De Silva A.K.M. and J. A. McGeough (1998) Process monitoring of electrochemical micromachining, Journal of Materials Processing Technology, 76, 165-169.

[5] Bhattacharya B., B.Doloi and P.S.Sridhar (2001) Electrochemical micro-machining: new possibilities for micro-manufacturing, Journal of Materials Processing Technology, 113, 301-305.

[6] Wang et al, Anjali V. Kulkarni and V. K. Jain, Micro fabrication using Electrochemical Spark Mechanical Engineering Department, Indian Institute of Technology, Kanpur-208016.

[7] Forster et al, De Silva K. M., H. S. J. Altena and J. A. McGeough**,** Precision ECM by Process Characteristic Modeling, Journals of precession engineering.

[8] Wang et al, MohanSen and Shan. H. S (2005) A review of electrochemical macro- to micro-hole drilling processes, International Journal of Machine Tools & Manufacture, **45**, 137-152.

[9] Mechanical properties of fly ash reinforced aluminium 6061composite IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP. 55-59

[10] Production and characterization Of Aluminium-Fly Ash Composite Using Stir Casting Method Department of Metallurgical & Materials Engineering National Institute of Technology Rourkela. Sudipt Kumar J. AnandaTheerthan

[11] Assessment of Mechanical and Corrosion Properties of Aluminium Reinforced With Fly Ash (Alfa) Metal Matrix Composites 2016 IJEDR | Volume 4, Issue 3 | ISSN: 2321-9939

[12] Aluminium-based metal matrix composites by stir casting: a literature review. Bharat Kumar, Jyoti V. Menghani - Int. J. of Materials Engineering Innovation 2016 - Vol. 7, No.1 pp. 1 - 14

[13] Fibre reinforcement of aluminium by squeeze casting: a summary of the state of the art. M.R. Jolly, G. Haour - Int. J. of Materials and Product Technology 1988 - Vol. 3, No.2 pp. 172 - 178

[14] Some observations on the mechanical properties of particulate-reinforced 6061 aluminium metal matrix composites. T. Das, P. R. Munroe, S. Bandyopadhyay - Int. J. of Materials and Product Technology 2003 - Vol. 19, No.3/4 pp. 218-227

[15] S. Das, Development of aluminium alloy composites for engineering applications, Trans. Indian Inst. Met, 57(4) (2004), 325-334.