Machining of Aluminium and Silicon alloys (AL6061/ SiC) Compos by Electrochemical Discharge Machining Process

Krishan Kadyan[1], Amit[2], Suryakant[3]
Department of Mechanical Engineering
M.Tech Scholar[1,2], Assistant Professor[3]
Institute of Technology & Sciences, Bhiwani, Haryana

Abstract- *For successfully completion in today's global market, there is a huge demand of rapid product development by reducing the lead-time between the designs of the product to its arrival in the door of the market. To respond to quickly adapt changes, manufacture of newly designed products requires several innovative manufacturing and assembling processes. Also, it is observed that for searching an advanced non-traditional manufacturing method which may help to reduce machining time factor with such composite. To meet the requirement of micro machining of such materials, it is essential to design a new manufacturing method. In addition, this paper also uses MMC test results to analyse the development of Electrochemical Discharge Machining (ECDM) set up to performance characteristic.*

Keywords- Electrochemical Discharge Machining (ECDM), electrochemical machining (ECM), Electric Discharge machining (EDM).

I. INTRODUCTION

Due to the rapid advancement and growing need for high power materials in technologically modern industry and supported by the industrialisation in the field of material science, there has been an huge demand in the availability and use of machine and engine materials. Conventional manufacturing processes are sufficient for machining of such materials. Electrochemical Discharge Machining, Electrochemical machining, Electric Discharge machining are such manufacturing processes which is widely accepted for the manufacturing of electrically conductive materials.

Electrochemical manufacturing process is one of the recent and potentially the most adaptable conventional manufacturing process. ECM process is an extension of an already known process of electroplating with some modifications but in reverse direction. A shaped tool or electrode is used in the process which forms cathode. The work piece forms anode. Principal of ECM is based on Faraday Laws of Electrolysis. The tool and work piece are held close to each other with a very small gap of 0.5 mm between them. Electrical Discharge Machine is also known as spark over initiated discharge machining, spark erosion machining or spark machining. Principal of EDM is that the work piece and the tool are separated by a gap called spark gap. The gap is filled by dielectric fluid. The spark gap usually varies from 0.005mm to 0.05mm. DC voltage of 50V to 450V is applied and the gap is ionized. The consequent drop in the resistance and discharge of electric energy results in electrical breakdown. Electrochemical discharge manufacturing processes is basically a hybrid process which is just a combination of ECM and EDM manufacturing process, as it includes the features of both the process. Cathode and anode electrode are manufactured by electrochemical discharging manufacture process and the gap between tool and work piece are regularly maintained by automatic feed mechanism.

ELECTROCHEMICAL MACHINING: ECM is used as 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 is made the anode. An electrolyte which is dipped through small gap which is maintained between the tool and the work piece. The chemical properties of this electrolyte are such that the constituents of the work material go into the solution by electrolytic process but do not plate on the tool.

ELECTRIC DISCHARGE MACHINING: Electric Discharge machining is the removal of materials conducting electricity by electrical discharges between two electrodes. A dielectric fluid being used in the process. The aim of the process is controlled removal of material from the work piece.

II. RELATED WORK

Frank Muller and John Monaghan [1], studied on modern machining of particle reinforced to design the metal matrix composite. Jasmin Hashim et al. [2], studied a new approach of producing cast MMC. M K Surappa [3], presented an overview of AMC material systems on aspects relating to processing, microstructure, properties and application. D. Landolt et al. [4], reviewed the role of mass transport, current distribution and passive films for shape control and surface smoothing is discussed. S. Das [5], described the wear behaviour such as sliding wear, abrasive wear, erosion-corrosion etc. of Al alloy-SiC composite. Yan et al. [6], studied and explore the impact of the manufacturing properties of pure titanium metals by using an electrical discharge assembling processes with the addition of urea into the distilled water. Later on Sen & Shan [7], reviewed the electrochemical macro to micro hole drilling process. Anjali V. Kulkarni [8], purposed a synchronised, transient temperature and current measurements have been carried out. Mahardika and Mitsui [9], purposed a new method of monitoring micro-electric discharge machining process. After that Manoj Singla et al. [10], studied a modest attempt has been made to develop aluminium based silicon carbide particulate MMCs. Recently, S.S. Sundarram [11], also developed a novel µ ECM utilizing high frequency voltage pulses and closed loop control. Stainless steel SS-316L and copper alloy CA-173 were chosen as the work piece materials.

III. DESIGNING METHODOLOGY

This section focused on designing methodology and working of ECDM. To predict the nature and impact of different electrochemical discharge manufacturing parameters on the machining of salient features for example such as material volume removal rate, average depth in radial overcut, a series of observation are carried out by using dynamic set of parametric values. This section also briefly explain the plan layout of experiment i.e. work piece materials electrolyte used, size of electrolyte, experimental and design methodology, and experimental layout design, input-output parameter settings, equipment used to measure the micro hole manufacturing process during electrochemical discharging machining.

IV. LAYOUT FOR EXPERIMENTATION

An electrochemical discharge machining set up was developed and fabricated for conducting the experimental investigation. Different drilling test were conducted on AL 6061/ SiC- MMC specimens using developed ECDM setup. The experimental observation carried out by using the Taguchi method using robust design L16 (45) orthogonal array. The sample material volume removal rates are obtained by differentiating the weights of work pieces before and after observation each hole. Different micrograph of the micro holes was taken utilizing Scanning Electron Micrograph to analyse the surface texture of the hole.

V. RESULTS AND DISCUSSIONS

A series of experiments have been carried out by varying different parameters and presented the results for discussions. Different graphs have been plotted to analyze the effect of various electrochemical discharge manufacturing (ECDM) parameters on the machining features e.g. material volume removal rate, average depth of radial overcut. The test results are analyzed to identify the most effective parameters of the developed ECDM setup. Different scanning electron micrographs SEM showed that the characteristics of the generated holes during ECDM operation.

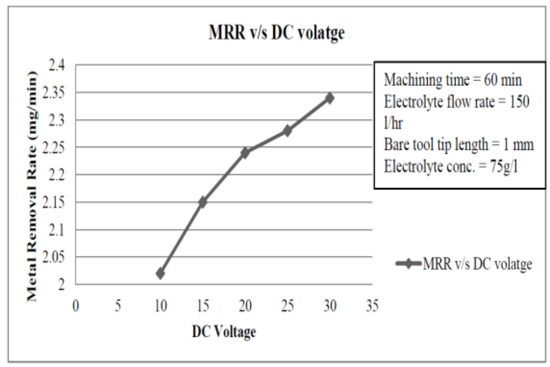

Fig-1: Effect of DC voltage supply on material removal rate

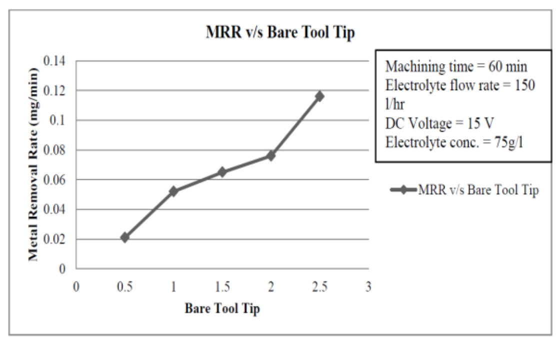

Fig-2: Effect of bare tool tip length on material removal rate (MRR, mg/min)

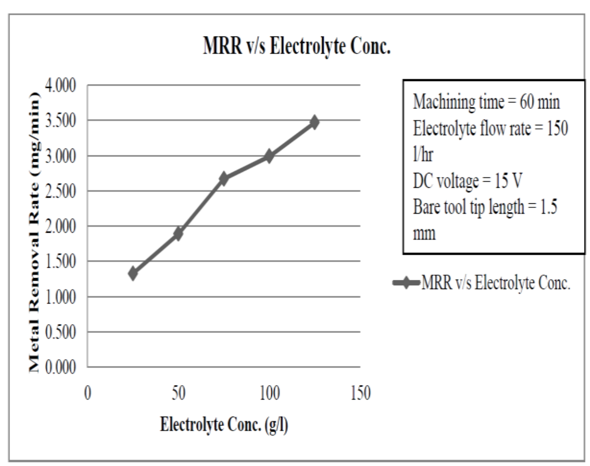

Fig-3: Effect of electrolyte concentration on material removal rate (MRR, mg/min)

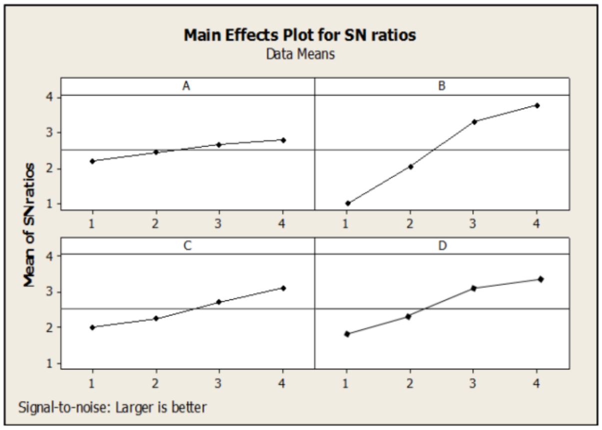

Fig-4: Shows the S/N ration by their factor level for MRR, mg/min

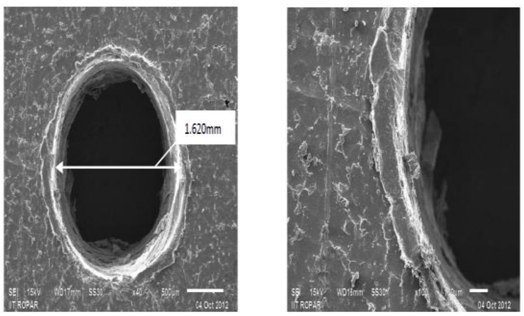

Fig-5: SEM of generated hole at 25 volts DC supply voltage

The above figure concludes that a Scanning Electron Micrograph of obtained microhole during micro drilling of AL 6061/SiC (18%)-MMC. The SEM graph showed that the actual conditions of micro machined hole with the following cutting parameters setting: 15 volts Direct Current supply voltage, 130 l/hr electrolyte flow rate, and 2 mm bare tool tip length and 125 g/l electrolyte concentration utilizing 1.6 millimetre diameter micro tool for 60 min control drilling. From the above SEM graph, it is observed that edges of micro hole are irregular in nature due to irregularity in spark. Micro hole produced is very rough in nature due to high electrolyte flow rate.

V. CONCLUSION

On the basis of the observations results during manufacturing of holes on electrically conductive high strength Aluminium 6061/Silicon Carbide (10%) (AL6061/SiC (10%))-MMC, we showed that DC voltage and electrolyte concentration are the most significant parameters on material volume removal rate with 63.88 % and 35.71 % contribution respectively. To attain maximum material volume removal rate, the optimistic parameter combination is A4B4D4C4. For average depth radial overcut, the optimal parametric combination is A1C1B1D1. From the SEM experimental graphs, it is concluded that overcut around the manufactured hole but this can be maxiimized by controlling the gap between the bare tool tip and work piece. It is also observed that overcut and dimensional ovality was high that may arise due to cause of deflection of tool and increases in the sparkling area during drilling. From the SEM graph of through holes, it is concluded that the irregularities around the surface of the hole are noticed, which may reveals that the very fine micro hole machining is really a typical exercise on electrically conducting composite material.

FUTURE PROSPECTS

The further research work has been carried out on manufacturing of holes on electrically conductive AL6061 MMC by utilizing the developed Electrochemical Discharge Manufacturing setup. Apart this, there is quick demand to investigate surface roughness during drilling of holes on electrically conductive AL6061 MMC by utilizing the developed Electrochemical Discharge Manufacturing setup.

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