ELK ASIA PACIFIC JOURNAL OF MECHANICAL ENGINEERING AND RESEARCH- SPECIAL ISSUE
ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

ELK
Asia Pacific Journals

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

ELECTRICAL DISCHARGE MACHINING ON METAL MATRIX COMPOSITES: A REVIEW

Ashish Singh	**D. K. Singh**	**Anjani Kumar Singh**
Department of Mechanical Engineering Madan Mohan Malaviya University of Technology, Gorakhpur-273010	Department of Mechanical Engineering Madan Mohan Malaviya University of Technology, Gorakhpur-273010	Department of Mechanical Engineering Madan Mohan Malaviya University of Technology, Gorakhpur-273010

ABSTRACT

Metal matrix composites (MMC) are advanced develop materials that well-known for their excellent mechanical properties like high specific strength, light weight and better wear resistance over their unreinforced alloys. These composites are widely utilized in aerospace and automotive industry. The conventional machining technique can not meet the requirement due to enhancement of strength and hardness of new material. The traditional processes used to machine these materials causes high tool wear rate. The non-traditional machining processes used which suitable for these conditions. Electrical discharge machining (EDM) exhibits better potential to machine complicated shapes and dimensional accuracy. EDM is used to enhance the material removal rate (MRR) and reduce the tool wear rate (TWR) to obtain better surface roughness (SR). This paper shows a review of MMC machined by EDM.

Keywords: *Metal Matrix Composites, Electrical Discharge Machining, Material Removal Rate, Tool Wear Rate, Surface Roughness.*

INTRODUCTION

Electrical discharge machining is a non-traditional material removal technique which is used to remove material in form of crater to produce complicated shapes and contour like punches, molds, finishing parts of aerospace, dies, surgical and automotive components[1]. This non-conventional process is widely employed for the machining of electrical conductive material without considering their shape, hardness and toughness. Larger separation between the electrodes erode more work material but machined surface have poor surface quality. EDM properties are closely connect by material property and design of electrode. The electrode is combination of two parts electrode tool and holder. The electrode are mainly prepared by conventional machining process, but complex shape may be manufactured by casting and electroforming. In die-sinking EDM Electrode either fixed or a rotary type works in association with a CNC to trace the path of different EDM profile. Electrodes are electrical conductive in nature both tool and workpiece are connected to the different terminal of power sources. The workpiece is mounted at positive terminal (anode) and tool is mounted at negative terminal (cathode). This type of arrangement of tool and workpiece material is known as straight polarity.an electric field is generated in

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

electrode gap which causes to motion of electron from cathode to anode because of high voltage difference. When tool and wokrpiece are brought closer to each other, an electrical discharge in form of spark bounced across the cathode to anode due to voltage difference [2]. The influence of process parameters on desired response characteristic like MRR, TWR, surface roughness and machinability have been investigated by various researchers. Mohan et al. [3] have investigated the influence of pulse on time, spark current and air gap voltage on MRR of a composite material.

Material removal mechanism of electrical discharge machining process: In EDM material is generally detached by the action of erosion caused by sparking generate between the tool electrode and workpiece that are immersed in dielectric fluid as shown in figure1. The intensity of discharge is high between the electrodes which generates very high temperature causes melting and evaporation of two electrodes hence material removal take place. [2]

Process parameters of electrical discharge machining: The process parameter of electrical discharge machining categorized into two way:

1) Electrical parameters
2) Non electrical parameters

Major electrical parameters are peak current, discharge voltage, pulse interval, pulse duration, polarity and electrode gap.

Discharge voltage is connected with breakdown strength of dielectric and inter electrode gap. Peak current is observed as most affective process parameter. The value of current rises up to pre-set value during every one pulse on-time. It is responsible directly for material removal. Peak current contains energy for melting and evaporation of material from both electrodes. The maximum value of current is controlled through the cut surface area. Greater peak current is provided during rough machining. Peak current considered as most significant parameter due to machined structure is replica of tool electrode [1].

Pulse duration is also known as pulse on-time. It is measured in unit of microseconds. The amount of material remove per unit time determined by energy created during pulse on-time [5]. Larger value of pulse on-time permit high amount of heat to sink through the workpiece and grow over, which cause broader recast layer and the larger depth of heat affected zone. Pulse interval is also called as pulse off-time. It is the time in which allows the melted particles to coagulate on the workpiece and flush away by dielectric fluid. Pulse off-time predominately affected by speed of machining and solidity of cut. Smaller the off-time, as results in greater material removal [6]. Spark gap is maintain with help of tool electrode servo mechanism. It is developed to react effectively with the average voltage gap [7]. The polarity of electrode either positive or negative. Mostly, the polarity is decided by observations. It is depend upon material of tool and workpiece, also the intensity of current [1]. The pulse is generally rectangular shape may be also other shapes developed. The trapezoidal wave pulse have relatively less tool wear [8].

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

Non-electrical parameters:

Flushing pressure of dielectric, work material rotation and tool rotation are the non-electrical parameters of EDM. These parameters influence the performance measures. Experiment to the flushing pressure measures its affect on tool wear and surface roughness also behave like a coolant and play important role to flush away debris from the gap between electrodes [9-11]. Experiment results concluded that during rough machining the flushing pressure influences tool wear rate (TWR) and material removal rate (MRR), however in finishing process, it affects the surface roughness. If flushing pressure is increased cause increased in both TWR and MRR [12]. Crack density and recast layer also affects by the flushing pressure which can be reduced by determining an optimal flushing pressure [10].

Classification of EDM:

1) Die-sinking EDM
2) Wire-cut EDM

In die-sinking EDM process, firstly the electrodes are attached to their places on the machine parts which are work bench and tool holder. Electrodes should be electric conductive in nature. Than the electrodes are submerged inside the dielectric fluid, which are EDM oil/ kerosene/ transformer oil. After that set the process parameters on the CNC controller for material removal on then work material to obtain desired shape and size. Each of the spark energy discontinuous and controlled enough to vaporize and melt within the thin gap from the work material. In this process the discharge current varied within the range 0.5 to 4006 A, AT 50-300V voltage range and pulse on time varied from 4 to 2000 micro seconds [13].

The wire-cut EDM process is also known as electrical discharge wire cut process utilised for producing complicated shapes using a thermoelectrical energy for eroding the material with the help of thin single metal wire immersed inside deionised water which is purpose for conduct electricity. Each harder material can be machine by wire-cut EDM process, however the material should have conductive to the electricity. The metal wire is generally made up by copper or brass. The diameter of wire in the range of 0.25 to 0.50 mm. the electrode wire is move by the use of wire spool which is revolved in same direction to the wire string. The wire speed is up to 4 m/min. the spark energy is created within the wire electrode and workpiece [13].

COMPOSITES

A composite material consist two or more than two materials mixed together each having definite chemical composition and distinct phase, also different physical and chemical properties. Every combined material immiscible to each other [14].primary phase of this material known as reinforcement and secondary phase as matrix. The amount of reinforcement can be less than or equal to amount of matrix. The reinforcement is imbedded within the matrix in order to improve the mostly properties such as physical, chemical, mechanical and tribological properties of a composites. The matrix confine the reinforcement together to restrict reinforcement phase become scattered.

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

One of the example of composite is concrete made by the combining cement, sand and stone particles where cement behave like a matrix which binds reinforcement (sand and stone).here in this example there are two different reinforcement added to the matrix phase, such composites are called as hybrid composites. Hence hybrid composites are defined as those composite in which reinforcement phase is more one material.

Classification of composites: Composites are classified in two ways [15]:-

1) Based on reinforcement
2) Based on matrix

According to the type of reinforcement, composites are further categories into two ways:

I. Particle reinforced composites
II. Fibre reinforced composites

In particle reinforced composites the reinforcement is in discontinuous form, randomly oriented. The sizes of particles are measured in micrometre or nanometre. The particle is involved in sharing of load with matrix. Generally the particle have dimensions that are equal in around all directions. The shape of reinforced particle can be regular or irregular as desire to the requirement of composites [15].

According to the type of matrix composites are further categories into three types:-

I. Metal matrix composite
II. Ceramic matrix composite
III. polymer matrix composite

Metal matrix composites consists of metal as base material which is called as matrix and the other material known reinforcement can be metal or non-metal. The Composites in which metal is act as a matrix, the reinforcing phase mostly used in form of powder either nano powder or micro powder. Matrix can be used in any form like chips, powder, billets and bricks etc. the reinforcement utilized to improve the overall performance of metal matrix composite such as hardness, increase toughness and strength, more resistant to temperature and increase corrosion and wear resistant [16]. This type of composites are widely used in marines, aerospace, automobiles and constructions etc.

RESEARCH IN EDM OF METAL MATRIX COMPOSITES

Velmurugan c et al. [17] performed experiments on EDM to the Al-6061 matrix based composite mixed with 4% graphite and 10% silicon carbide. MRR, SR and TWR observed as process responses. They concluded that MRR is increased in increasing of peak current. Flushing pressure and pulse duration are decrease in increment of voltage. TWR affected by voltage and peak current. TWR is decrease in increase of pulse duration and voltage. Hyun et al. [18] experimented on EDM to the hybrid MMC reinforced with $Al_2O_3$and CNTs for creating micro holes utilizing EDM. They concluded that for attain the accurate machining, material conductivity and uniform distribution of reinforcement are necessary. Suresh et al. [19] investigated the affect of input parameters of EDM on Al-6351/SiC/ B_4C hybrid MMC. They concluded that rising the peak current cause increase in TWR and undesirable SR is obtained.

Aharwal K.R et al. [20] investigated the effect of process parameters of EDM on

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

aluminium silicon carbide metal matrix composite (MMC) as workpiece and copper as tool. They concluded that material removal rate obtains optimum values, if current is higher and voltage is less. The surface roughness is better when both current and voltage are low. Kandpal et al. [21] studied the machining characteristics of Al-6061/10% Al_2O_3 metal matrix composite using EDM. They controlled the process parameters to obtain maximum MRR and minimum TWR. To find the optimal value of input parameters analysis of variance is performed. A Dey et al. [22] examined the machinability of composite material (Al-6061/anosphere) on EDM. They observed for different collection of process parameters were measured responses like EWR, MRR and SR. grey-based methodology is used to choosing the optimum combination of input parameters.

Hung et al. [23] experimented for the aluminium based MMC with reinforcement of silicon carbide. They found that SiC particles defend the matrix aluminium to vaporized and reduce the amount of material removal per unit time. The current is dominated factor for surface roughness of machined surface. Chetan Roy et al. [24] investigated the influence of different input parameters like current, pulse duration, aluminium powder concentration in kerosene and its response to output parameters. The desirability function multi-objective approach is used to optimized the input parameters. Aluminium powder improves the SR but reduce the MRR because of repeated short circuiting. M Rozenek et al. [25] studied the affects of process parameters on machining of Al/SiC and Al/Al_2O_3 MMC during WEDM. The characteristics of WEDM on MMC are identical as in case of matrix material (Al alloy). The cutting speed of WEDM significantly influence by type of reinforcement used.

Mohanty et al. [26] experimented upon Al/12% SiC composite using EDM. In this paper response surface methodology (RSM) is used to mathematical modelling and developing the relation between input parameters and ouputs. Analysis of variance is adopted for validate the results. Gangadharudu et al. [27] attempted to machine Al/ alumina metal matrix composite utilizing EDM with addition of aluminium powder in kerosene dioelectric. Results concluded an improvement in MRR and decrement in SR contrasted to other traditional EDM. They peformed multi-objective optimization (Grey-PCA) to obtain optimal set of input parameters for minimum SR and maximum MRR. Rajessh et al. [28] showed the influence of process parameters like mesh size of SiC, rotational speed of tool and diameter of hole on the responses i.e the MRR, TWR and radial overcut. They founded during machining of Al-7075/ 10% SiC composite materal. The rotational speed of tool was deviated from 0 to 460 rpm and diameter of hole between 0 to 6 mm.

CONCLUSIONS

IN THIS REVIEW INFLUENCE OF PROCESS PARAMETER HAVE BEEN STUDIED FOR THE METAL MATRIX COMPOSITE MATERIALS WHICH ARE MACHINED BY EDM. THE COMPOSITE MATERIALS REINFORCED WITH

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

Al_2O_3 AND SIC ARE WIDELY DEMAND IN AEROSPACE AND AUTOMOTIVE INDUSTRY. THIS REVIEW PAPER CLEAR EXAMINED WHICH ARE THE PROCESS PARAMETERS IMPORTANT FOR THESE MATERIALS TO OBTAIN BETTER RESPONSES. THE DIFFERENT INVESTIGATION PERFORMED ON EDM, THE OBJECTIVES ARE THE IDENTICAL FOR IMPROVING THE CAPACITY OF MACHINING CHARACTERISTIC TO ACQUIRE DESIRE PRODUCT.

REFERENCES

[1] *HO KH, Newman. State of the art electrical discharge machining. International Journal of machine Tools and Manufacture. 43 1287-1300, 2003.*

[2] *Vijay K. Jain. Advanced Machining Processes. Allied Publishers Private Limited, New Delhi, 2007.*

[3] *Mohan, Rajadurai and Satyanarayana. Effect of SiC and rotation of electrode on electrical discharge machining of Al-SiC composite. Journal of Materials Processing and Technology. 124 297-304, 2002*

[4] *Dharamjeet Singh and Kanwaljeet Singh. Electrical discharge machining: a review. International Journal of Current Research. 9 (8) 55575-55577, 2017.*

[5] *Kansal, Singh S, Kumar P. Parametric optimization of powder mixed electrical discharge machining by response surface methodology. Journal of Material Processing and Technology. 16 (3) 427-436, 2005.*

[6] *Fuller JE. Electrical discharge machining. ASM Machining Handbook. 16 557-564, 1996.*

[7] *Crookall, Heuvelman. Electro-discharge machining-the state of the art. Annals of the CIRP. 20 (1) 113-120, 1971.*

[8] *De Bruyn HE. Slope control- a great improvement in spark erosion. Annals of the CIRP. 16 183-186, 1968.*

[9] *Lonardo, Bruzzone. Effect of flushing and electrode material on die-sinking EDM. CIRP Annals-Manufacturing Technology. 48 (1) 123-126, 1999.*

[10] *Wong YS, Lim, Lee. Effect of flushing on Electro-discharge machined surface. Journal of Material Processing and Technology. 48 299-305, 1995.*

[11] *Anonymous. Dielectric fluids for Electro-discharge machining. British Petroleum Company UK.1982.*

[12] *Guu, Hocheng. Effects of workpiece rotation on machinability during electrical discharge machining. Journal of Material Manufacturing and Processing. 16 (1) 91-101, 2001.*

[13] *Bhattaryya, Gangopadhyay and Sarkar, Modelling and analysis of EDM ED job surface integrity, Journal of Material Processing Technology 189.1, 169-177, 2007.*

[14] *Singh Bains et al. Fabrication of machining of metal matrix composites: a review. .Material and Manufacturing Processes. 2016.*

[15] *William D Callister, Jr. Material Science and Engineering: An Introduction. Department of Metallurgical Engineering, the University of Utah.*

[16] *Srinivasulu, Tejaswi. Mechanical properties of polymer composite Materials. International Journal of Research in Engineering and Technology.*

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

[17] *Valmurugan, Subramanian, Thirugnanam and Ananadavel. Experimental investigations on machining characristics of Al-6061 hybrid metal matrix composites processed by electric discharge machining. International Journal of Science and Indrustrial Research. 8 (3) 87-101, 2011.*

[18] *Seok Tak, Seug Ha, Jun Lee, Hyung Woo, Jeong, Chang Kang. Characteristic evaluation of hybrid materials for micro-electrical discharge machining. Transaction of Nonferrous Metals Society China. 21 28-32, 2011.*

[19] *Suresh Kumar, Uthayakumar, Kumaran, Parameswaramss. Electric-discharge machining of Al (6351)/5% SiC/10% B_4C hybrid composite: A Grey Relational Approach. Modelling and Simulation in Engineering, Hindawi Publishing Corporation. 2014. Article ID 426718.*

[20] *Aharwal K.R, Sitaram and CM Krishna. Optimization of material removal rate and roughness in edm machining of MMC using genetic algorithm. Material Today Proceedings. 5 5391-5397 2018.*

[21] *Bhaskar Chandra Kandpal, Jatinder Kumar and Hari Singh. Optimization of electrical discharge machining Al-6061/10% Al_2O_3 composite using taguchi optimization technique. Material Today Proceeding. ICMPC 5 4413-4420 2018.*

[22] *A Dey, S Debnath and Km Pandey. Optimkization of electrical discharge machining process parameters for Al-6061/anosphere composite using grey based hybrid approach. Transaction of Non Ferrous Metals Society China. 27 998-1010. 2017.*

[23] *Hung, N. P., Yang, L. J., Leong and K. W. electrical discharge machining of metal matrix composites. Journal of Materials Processing Technology. 44(3-4) 229-236.*

[24] *Chetan Roy, Khalid Hussain and Kuppan P. machinability of Al/ 10% SiC / 2.5% TiB2 MMC with powder mixed electrical discharge machining. Proceedia Technology. RAEREST. 25 1056-1063, 2016.*

[25] *M Rozenek, J. Kozak, L. Da Browski and K. Lubkowski. Electrical discharge machining characteristic of metal matrix composite. Journal of Materials Processing Technology. 109 (3) 367-370. 2001.*

[26] *Shalini Mohanty, B.C Routara and R. K Bhuayan. Experimental investigation of machining characteristic of Al/ 12% SiC composite in electro-discharge machining. Material Today Proceeding 4 8778-8787. 2017.*

[27] *Gangadharudu, Sahoo, Gangopadhyay and Viswas, Modeling and multi-objective optimization of powder mixed electric discharge machining process of aluminium/alumina metal matrix composite, Engineering Science and Technology an International Journal.1-5, 2015.*

[28] *Purohit, Verma and Praveen, Electrical discharge machining of Al7075/10% SiC composites using rotary tube brass electrode, International Journal of EngineerinSg Research and Application. 2(2), 411-423, 2012.*

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

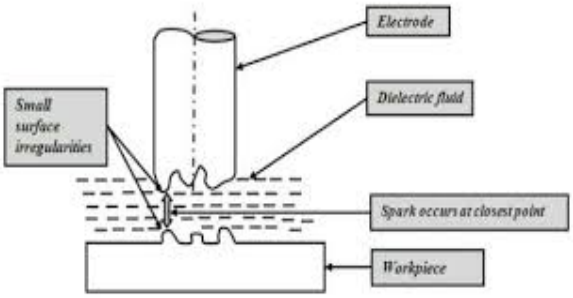

Figure 1: *Material removal mechanism of electric dischare machining. [4]*