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Study of Influence of Process Parameters in Electric Discharge Machining of Aluminum – Red Mud Metal Matrix Composite

Chinmayee Kar, B.Surekha* , Hemalatha Jena, Suvan Dev Choudhury

School of Mechanical Engineering, KIIT University, Bhubaneswar, 751024, India

Abstract

The present paper intends an experimental investigation and mathematical modelling of electrical discharge machining (EDM) of aluminium metal matrix composites. The experiments are conducted based on the concept of central composite design of experiments to estimate the effect of machining process parameters on responses. In the present experimental investigation discharge current, open circuit voltage, pulse-on-time are treated as the input process variables and material removal rate, electrode wear rate and radial over cut are considered as the responses. Fifteen experiments with 3 replicates for each experiment are conducted on aluminium metal matrix composites. The work material which is used in the present study consists of Al7075 and 6% red mud by weight as matrix and reinforcement, respectively. During EDM, it is observed that the discharge current and pulse on-time have significant effect on machinability characteristics of Aluminium metal matrix composite (AMMC). The two factor analysis offers useful information with minimum deviation for controlling the machining parameters to improve the accuracy of the EDMed components.

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Keywords: Electrical discharge machining, material removal rate, tool wear rate, radial overcut, response surface methodology

1. Introduction

Aluminum Metal Matrix Composites (AMMC's) are new age group engineering materials which exhibits superior physical and mechanical properties compared to non-reinforced alloys. This makes them suitable for extensive range of applications in automotive, aerospace and defense industries. These composite materials have desired properties such as high strength to weight ratio, high toughness, low value of coefficient of thermal stability and high corrosion

* Corresponding author. Tel.: 9776220902.
E-mail address: surekhafme@kiit.ac.in

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Nomenclature

AMMC	aluminium metal matrix composites
D_t	diameter of the tool
D_w	diameter of the work piece
EDM	electric discharge machining
EWR	electrode wear rate
I_p	peak current
MRR	material removal rate
ROC	radial over cut
T_a	weight of tool after machining
T_b	weight of tool before machining
T_{on}	pulse on time
V_g	gap voltage
W_a	weight of work piece after machining
W_a	weight of work piece before machining

resistance. It is important to note that the machining of complex shapes of high strength materials like composites, ceramics etc., is very difficult task when using conventional machining process. In the present research work, authors made an attempt to machine the AMMCs by using EDM process, to develop a nonlinear regression relationship between process parameters and various responses. Although copper and brass are mostly used as the electrode material because of their good electric conductivity, sometimes graphite can also be used as a potential electrode material due to its high melting point, high wear resistance and conductivity. It is important to note that the most of the researchers have preferred brass, copper and graphite as electrode material in EDM process

In the past, researchers tried to prepare various types of aluminum metal matrix composites [1, 2 and 3] to introduce tailor made properties that are essential for their functioning in various applications. These materials offer high resistance for machining with the help of conventional machining processes. Therefore, researchers around the world used non-conventional machining methods to convert the blanks of AMMCs into useful products. Prakash et al. [4] prepared A413/flyash/B_4C hybrid composites and studied the machinability of the developed composites using wire EDM. They studied the effect of various input process parameters namely pulse on time, gap voltage, pulse off time, percentage of reinforcement and wire feed on MRR and surface roughness. Siva et al. [5] developed in-situ Al-Al_2O_3-SiC AMMCs and studied their mechanical properties. They also conducted experiments to investigate the machinability of these prepared hybrid composites. Velmurugan et al. [6] used prepared Al6061/10%SiC/4%graphite hybrid metal matrix composites using stir casting process and studied the machining characteristics using EDM. They also used scanning electron microscope to study the surface characteristics of machined surface. Moreover, Shyha and Rudd [7] also did experiments to study the machining of aluminum matrix composites reinforced with silicon carbide particles using EDM process after conducting the experiments with the help of full factorial design of experiments. Harish et al. [8] and Srikanth and Kumar [9] conducted a huge literature survey and concluded that the machining of aluminum hybrid metal matrix composite is overcome by the Electric discharge machining process. Further, Rajesh et.al [10] did their experimental investigation on the red mud mixed AMMC. In their research work, they determined the optimal set of process parameters of CNC lathe machine for a set of quality characteristics with the help of Taguchi methodology. They also tried to predict the optimal set of parameters by principal component analysis [11] to improve the performance of the CNC lathe machine on AMMC. Further, Rajesh et.al [12] conducted the experimental investigation on the Al-12% SiC MMC, which was made by stir casting process. Required number of experiments were decided based on the concept of response surface methodology. In addition to that, ANOVA for all the responses had also been conducted. Suresh et al [13] conducted experiments on the machining of MMCs using EDM. In their work, Al 6351 was used as the matrix material and silicon carbide (SiC) and boron carbide (B4C) was used as the reinforcing materials. Multi response optimization was used to find the optimal set of parameters to speed up the machining of high strength aluminum metal matrix composite. Further, Rao [14] manufactured the AMMCs with rice husk ash and red mud particles as