Parametric Effect on Electro Discharge Deposition of Z41A Magnesium Alloy with WC/NI Powder Metallurgy Electrode

U. Elaiyarasan
Dept of Mechanical Eng-
Karpaga Vinayaga College of Eng & Tech

C. Senthilkumar
Dept of Mechanical Eng-
University College of Eng

V. Satheeshkumar
Dept of Mechanical Eng-
Government college of Eng

R. Harishankar
Dept of Mechanical Eng-
Karpaga Vinayaga College of Eng & Tech

J. KeatsAvinash
Dept of Mechanical Eng-
Karpaga Vinayaga College of Eng & Tech

Abstract:- **Aim of this paper is to study the influence of WC/Ni powder metallurgy electrode on the substrate of ZE41A magnesium alloy by Electrical Discharge deposition (EDD). A main aspect of EDM is surface modification by depositing the electrode materials on the workpiece with dielectric medium. In this investigation, the electrode is prepared with WC and Ni powders by powder metallurgy (P/M) technique and ZE41A magnesium alloy is used as workpiece material. Different parameters such as compaction load (CL), current (I) and pulse on time (Ton) during EDC on material deposition rate (MDR) is studied. Central composite design of response surface methodology is proposed to design and plan the EDD experiments and to study the influence of various parameters on EDC. From the results it can be observed that the MDR increased when increased the current and pulse on time. Conversely it is decreased when increased compaction load.**

Keywords: ZE41A magnesium alloy, Electrical discharge deposition, response surface methodology, Powder metallurgy, material deposition rate,

1. INTRODUCTION

Electrical discharge machining (EDM) is one among the non conventional machining process used to machine hard materials [1]. EDM uses electric discharge for material removal and also for metal deposition. EDM not only used for making dies and press tools, automotive and aerospace but also extended its capabilities in the area of surface modification for producing uniform coating on the workpiece [2,3]. In this regard electrical discharge deposition (EDD) is introduced in recent year to create hard layer coating on the workpiece using ordinary EDM [4]. EDC can be used to deposit hard layer in the complicated shapes of workpiece. EDC application is inadequate due to poor integrity of the substrate. The workpiece surface, much like normal EDM, is often characterized by high roughness, porosity and factors which limits the tri bological properties of coating [5]. For the surface modification the tool electrode is prepared by powder metallurgy (PM) route method and different optimization technique has been used to study the contribution of the EDM parameters [6, 7]. Krishna et.al [8] described the influence of powder metallurgy tool electrode on the mild steel surface. W75%and Cu 25% of 325 mesh size powders are used as tool electrode material. It can be observed that the highest MDR of 281mg/min has been achieved successfully at low compaction load. Lee et.al [9] prepared WC electrode under the compaction pressure of 100 to540MPa with sintering temperature of 1000°C for the surface modification and found that semi sintered electrode has very good deposition rate because bonding between the both particles is reduced than the fully sintered electrode. Simao et.al [10] used WC/Co partially sintered electrode and the EDC experimental works done with parameter of 1 to3 A, pulse off time and pulse on time of 20 µs with voltage range between 125 to 270 V. Finally improved average layer thickness and surface hardness are 30 µm and 1319 HV respectively. Wang et.al [11] introduced green compacted titanium tool electrode for the surface modification of carbon steel. The parameters were set in the range of current 2.2-10 A, duty factor 5.88%, machining time 18 min, polarity as negative, electrode diameter is 12mm. James et.al [12] has analyzed the morphology and wear behavior of 304 stainless steel by single and multi layer electrical discharge coating .TiC, Si, Cu materials are used as electrode materials, Shell paraol 250 as dielectric, polarity as negative. Ti layer coating has the best wear results with lowest co efficient of friction. According to available literature, most of the researchers have concentrated on the surface modification by EDM using dielectric fluid as kerosene instead of EDM oil on the deposition process by EDM. In this work, electro discharge deposition technique is proposed to develop the coating on the magnesium alloy surface. Electrodes are prepared at various compaction loads with the composition of 70:30 for WC and Ni by powder metallurgy route. An effect of process parameters on material deposition rate in EDM is studied.

EXPERIMENTAL DETAILS

The experiment was conducted in ordinary conventional EDM machine using EDM oil as dielectric fluid with a green compact electrode consisting of WC70% and Ni30% powders through powder metallurgy (P/M) technique having 10 mm diameter. The workpiece material in this study is ZE41A magnesium alloy. The chemical composition of the workpiece material is shown in table.1. Due to wide range of factors, it was decided to set three factors, three levels and rotatable central composite design (CCD) matrix has been adopted for conducting the experiment. Before machining top and bottom faces of the work piece were ground to make flat surface finish. The machining was generally carried out for a fixed time interval of 10 min and then amount of material deposition rate (MDR) was measured by taking the weight of the workpiece before and after EDD. In the present investigation compaction load, current and pulse on time are consider as controlling variables for the material deposition rate (MDR) during EDD process.

Table 1 Process parameters used in this study

Parameter	Unit	Level		
Compaction load	MPa	150	175	200
Current	A	2	3	4
Pulse on time	μs	11	29	47

3. RESULT AND DISCUSSION

3.1 EFFECT OF COMPACTION LOAD ON MDR

Influence of compaction load on metal deposition rate is shown in Fig. 1. From the figure compaction load increases, MDR decreases. It is due to at lower compaction load bonding strength is low, hence large amount of materials freely eroded and deposited on the surface, hence MDR increased. At higher compaction load bonding strength is high, hence, less amount of material dislodging from the electrode and deposited on the surface which shows the decrease in MDR [8].

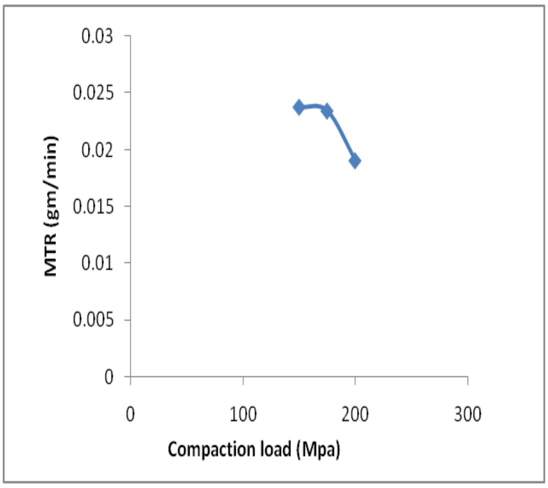

FIG.1. EFFECT OF COMPACTION LOAD ON MDR

3.2 EFFECT OF CURRENT ON MDR

Influence of current on metal deposition rate is depicted in Fig.2. Figure indicates that, when current increases the MDR decreases. This is because at lower level 2A causing the electrical discharge energy in the gap between the electrodes concentrated at a point and deposited of the electrode material on the workpiece surface, which could increase the weight of the workpiece during an EDM process. Conversely, with increase in discharge current from 3A to 4A spark discharge energy is increased to facilitate the action of melting and vaporization of ZE41A work piece and advancing the large impulsive force remove material rather than the deposition.

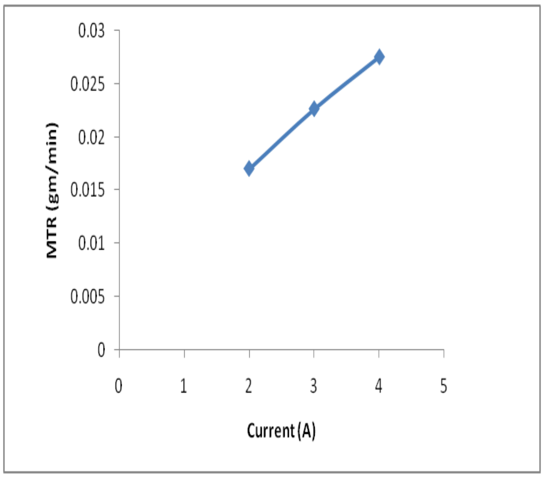

FIG.2. EFFECT OF CURRENT ON MDR

3.3 EFFECT OF PULSE ON TIME ON MDR

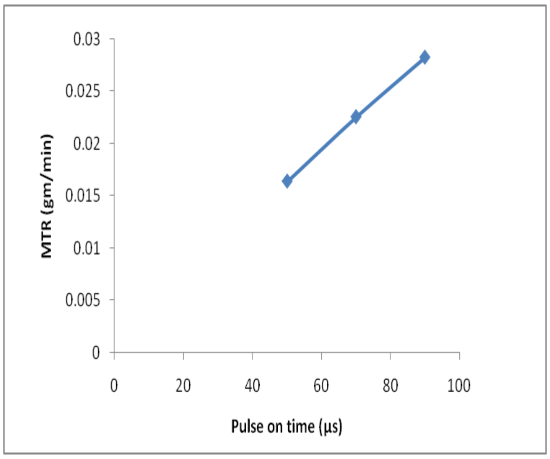

FIG.3. EFFECT OF PULSE ON TIME ON MDR

Fig. 3 showed that the influence of pulse on time on metal deposition rate. At lower pulse on time the material deposition rate is positive. At lower pulse on time, the deposition rate increasing gradually due to low ejecting force in the gap, leads to higher amount of material is dislodged from the electrode and deposited on the workpiece .With increase in pulse on time heat is concentrated on the workpiece surface causing removal of bigger volume of the molten metal and the deeper craters were formed. Moreover increase in pulse on time, diameter of discharge has increased and eroded higher amount of electrode and deposited on the workpiece.

CONCLUSION

In the present study, the MDR in EDD of ZE41A using WC70% and Ni30% P/M green compact electrode was studied. Compaction load, Current and pulse on-time have been employed to carry out the experimental study. It was observed that the MDR increased when increased the current and pulse on time because of large quantity of electric spark and plasma energy. Hence huge amount of material eroded from the electrode and deposited over the surface. Conversely MDR is low when increased the compaction, this is because bonding between the electrode particles is very high. Hence, small quantity of electrode materials eroded deposited on the work piece.

REFERENCE

[1] Erden A (1983) Effect of materials on the mechanism of electric discharge machining (E.D.M.). Trans ASME J Eng Mater Technol105:132–138.

[2] Anil, K.; Sachin, M.; Sharma, C.; Naveen, B. Research developments in additives mixed electrical discharge machining (AEDM): a state of art review. Materials and Manufacturing Processes 2010, 25 (10), 1166–1180.

[3] Hsin-Jen, C.; Kun-Ling, W.; Biing-Hwa, Y. Dry electrical discharge coating process on aluminum by using titanium powder compact electrode. Materials and Manufacturing Processes 2013, 28 (12), 1286–1293.

[4] A. Goto, T. Moro, K.Matsukawa, M. Akiyoshi, N. Mohri, Development of electrical discharge coating method, in : proceedings of the 13th international symposium for electromachiningISEM XIII, vol. 1, no. 5, 2000.

[5] Simchi, A. and H. Danninger, Effects of porosity on delamination wear behaviour of sintered plain iron. Powder Metallurgy, 2004. 47(1): p. 73-80.

[6] P. K. Patowari, P. Saha and P. K. Mishra: 'Taguchi analysis of surface modification technique using W-Cu powder metallurgy sintered tools in EDM and characterization of the deposited layer', Int. J. Adv. Manuf. Technol., 2011, 54, 593–604.

[7] Samuel, M. P. and Philip, P.K. (1996), Powder metallurgy electrodes for electrical discharge machining, Journal of Machine Tools Manufacturing, Vol.37, pp.1625-1633.

[8] M. Eswara Krishna and P. K. Patowari, Parametric Study of Electric Discharge Coating using Powder Metallurgical Green Compact Electrodes, Materials and Manufacturing Processes, 29: 1131–1138, 2014

[9] Lee, H. G; Simao, J; Aspinwall, D. K. and Dewes, R. C.(2004), Electrical discharge surface alloying, Journal of Material Processing Technology, Vol.149, pp. 334-340.

[10] Simao, J; Lee, H.G; Aspinwall, D.K; Dewes, R.C. and Aspinwall, E.M. (2003), Workpiece surface modification using electrical discharge machining, International Journal of Machine Tools & 42 Manufacture, Vol. 43, pp. 121-128.

[11] Z.L. Wang, Y.Fang, P.N. Wu, W.S.Zhao, K.Cheng, surface modification process by electrical discharge machining with a Ti powder green compact electrode, Journal of Material Processing Technology, Vol.129 (2002) 139-142.

[12] James W. Murray, Adam T. Clare, Morphology and wear behaviour of single and multi-layer electrical discharge coatings, Procedia CIRP 42 (2016) 236 – 239