Eph - International Journal Of Science And Engineering

ISSN (Online): 2454-2016
Volume 04 Issue 01 March 2018

DOI: https://doi.org/10.53555/eijse.v4i1.136

EFFECT ON PERFORMANCE MEASURES DURING DIE SINKER EDM OF AMMC BY EXTERNAL DIELECTRIC FLUSHING SYSTEM

Akhil Khajuria[1]*, Ankush Raina[2], Modassir Akhtar[3]
*[1]*Department of Mechanical Engineering, NIT Jalandhar, 144011, Punjab, India.*
[2]*School of Mechanical Engineering, SMVD University, Katra, 182320, J&K, India.*
[3]*CSIR - National Metallurgical Laboratory, Jamshedpur, 831007, Jharkhand, India.*

Corresponding author:
Email: akhilkhajuria40@gmail.com, Ph: +91-7837451401

Abstract:-
One of the important parameter in electrical discharge machining (EDM) of aluminium metal matrix composites is dielectric flushing pressure which is often not given attention due to its inbuilt presence inside the EDM set-up. Present work investigated the effect on material removal rate, tool wear rate and surface roughness with the variation of dielectric flushing pressure during EDM of 10wt.%Al_2O_3/AA2014. The composite was manufactured via mechanical stir casting route. For carrying out experiments on the available die sinker EDM to observe the influence of flushing pressure, a new external flushing system was developed to achieve high pressure. Kerosene oil was used as dielectric oil instead of EDM oil supplied with the machine. Only pulse current (I) was varied as an EDM input parameter considered whereas voltage (V), pulse on time (T_{on}) and pulse off time (T_{off}) were kept constant. It is found that material removal rate invariably increases with an increase in flushing pressure of dielectric oil whereas surface roughness behaves opposite. However, no significant differences are observed for tool wear rate.

Keywords: - *Die-sinker EDM; aluminium metal matrix composite; dielectric flushing pressure; material removal rate; tool wear rate; surface roughness.*

1. INTRODUCTION

The demand for light weight and rigid materials in automotive, defence and aerospace applications has given thrust to explore aluminium metal matrix composites (AMMCs). Enhanced fuel economy with powerful engines is the primary requirement these days from well-furnished vehicles that has resulted in the increased use of aluminium castings in engine components and chassis. Rigidity in these materials comes from enhanced fatigue, creep and wear properties due to the presence of hard particles or reinforcements like SiC, Al_2O_3, B_4C, TiC, ZrC, flyash etc. in them **[1-4]**. However, existence of such reinforcements also creates an issue for conventional machining methods which fail to produce good surface finish. Therefore, unconventional machining methods like EDM are employed to achieve adequate surface quality after machining **[5-8].** The main performance measures encountered during EDM of AMMCs are material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR) **[9]**. The input parameters generally investigated are pulse current, voltage, pulse on time and pulse off time. Several attempts have been given to optimise main performance measures in order to achieve high MMR **[10-13]**, low TWR **[14-16]** and low SR **[17-22]**. However, to obtain a best combination of these measures during EDM of AMMCs are still being investigated. On account of same; current work focuses on effect on performance measures during die sinker EDM of AMMC by variation of dielectric flushing pressure. The objective of present work is to examine effect on 10wt.%Al_2O_3/AA2014 composite manufactured by stir casting by variation of flushing pressure on MRR, TWR and SR.

2. Materials and methods

Literature on EDM of AMMCs infers that SiC has been used as reinforcement in majority of aluminium alloys. SiC has value of 9.5/10 on mohs hardness scale which makes it best ceramic reinforcement with a combination of aluminium alloy. Whereas Al_2O_3 has value of 9.0/10 on mohs hardness scale which is very near to SiC. Also, Al_2O_3 is cheap, easily available than SiC and gives same attributes like high temperature resistant, chemically resistant, electrically insulating and abrasion resistant material like SiC. For present experimental programme, AA2014 was used as the matrix phase with Al_2O_3 as particulate reinforcement to manufacture 10wt.%Al_2O_3/AA2014 composite by mechanical stir casting route. AA2014 is a copper based alloy and is typically employed for production of complex machined components due to its better machinability. Also, due to its high mechanical strength, it is extensively used in aerospace industry. Chemical composition of AA2014 is shown in Table 1. Mechanical and physical properties of AA2014-T6 (T6 refers that alloy is solution heat treated and artificially aged) and Al_2O_3 (99.9% Al_2O_3) used in this work are given in Table 2. Figure 2(a) shows the mechanical stir casting set – up used for manufacturing 10wt.%Al_2O_3/AA2014 composite whereas Figure 2(b) shows an EDM set – up incorporated with an external dielectric circulation system capable of providing different flushing pressures. To ensure maximum efficiency from the machine, kerosene oil was externally circulated. To fulfil this requirement, the new external flushing set up for ZNC-EDM was designed which bypassed the inbuilt flushing system of the machine. The new EDM dielectric circulation system was developed for 35 litres of dielectric fluid capacity for experimentation. The dielectric fluid is circulated by means of 0.5 HP circulation pump. Two gate valves are provided; one on the delivery side and another on the drain side of the tank. Gate valves are used there to control the flow of the dielectric. A hydraulic pressure gauge is installed in the set up to check the pressure of the dielectric fluid. A nozzle is used in the delivery pipe and is used to increase the pressure for flushing. Table 3 gives the machining conditions for experiments on ZNC-EDM.

Table 1 Chemical composition of AA2014

Element	Cu	Si	Mg	Fe	Zn	Ti	Ti+Zn	Mn	Cr	Al
Amount (wt. %)	3.9-5.0	0.5-0.7	0.3-0.8	0.7	0.25	0.15	0.2	0.40-1.2	0.1	90.4-95.0

Table 2 Mechanical and physical properties of AA2014 and particulate Al_2O_3

Material	Tensile Strength (MPa)	Modulus of Elasticity (GPa)	Vickers Hardness (Hv)	Density (gm/cc)	Melting Temp. (^{0}C)	Mean Diameter (µm)
AA2014	415	73.1	155	2.8	507-638	-
Al2O3	248	370	1365	3.96	2072	20-40

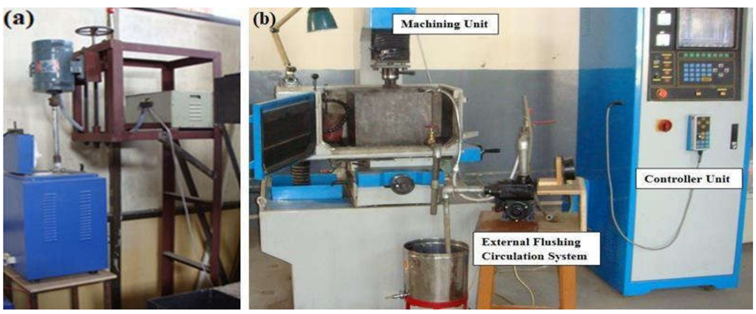

Figure 1 (a) Mechanical stir casting set up (b) Die- sinker EDM set up with external flushing

Table 3 Machining conditions for 10wt.%Al_2O_3/AA2014 composite

Workpiece	Tool electrode (dimensions in mm)	Depth of Cut (ZL, mm)	Polarity	Dielectric oil	Method of flushing	Flushing Pressure of dielectric
10wt%Al_2O_3/AA2014	Copper (Diameter = 12 and Length = 105)	0.4	Reverse	Kerosene	Side external	0.4 kg/cm² 0.6 kg/cm² 0.8 kg/cm²

Evaluation of MRR and TWR has been done as the ratio of the difference in weight of the work piece before and after machining to the machining time. SR was taken as Ra value (read from surface roughness tester 6210) from arithmetic mean of three observations taken at three distinguished points. Only pulse current (I) was varied as an EDM input parameter considered whereas voltage (V = 50 V), pulse on time (T_{on} = 150 µs) and pulse off time (T_{off} = 300 µs) were kept constant.

3. Results

Figure 3(a)(b)(c) show plots among current and performance measures MRR, TWR and SR respectively. Experimental data shown is for three flushing pressures of dielectric kerosene oil i.e. 0.4 kg/cm², 0.6 kg/cm² and 0.8 kg/cm². It can be clearly observed that MRR increases as pulse current and flushing pressure is increased at constant V, T_{on} and T_{off}. As a highest value of 0.8 kg/cm² flushing pressure is kept, a considerable improvement in MRR is seen. However, TWR behaves in a little different manner. Although effect of current is observed which increases TWR significantly but flushing pressure remains recessive and shows no major effect on TWR. An increase in current also increases SR, but an increment in flushing pressure shows opposite effect on SR than MRR. At minimum value of flushing pressure i.e. 0.4 kg/cm², a maximum value of SR of the order 25 µm is observed which indicates degraded surface quality at highest current of 30 amps. It may be noticed that at highest value of current, a maximum value of MRR is obtained but at the cost of SR at the same flushing pressure

4. Discussions

4.1 Effect of flushing pressure on MRR

Hike in MRR is due to the fact that high intensity sparks of energy assist in rapid melting.

This result in equal vaporization leading to bigger impulsive forces in the spark zone leading to an increase in MRR. Additionally an increment in MRR also results in fast material removal which is attributed to quick flushing action of dielectric kerosene oil which removes the debris generated in subsequent sparks of current.

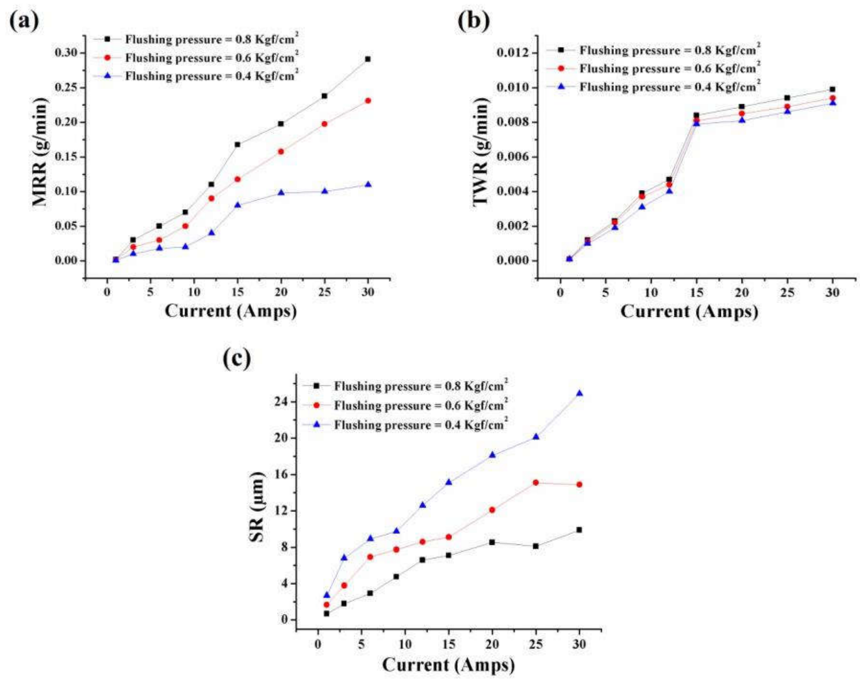

Figure 2 Variation in MRR, TWR and SR with respect to pulse current and flushing pressure of dielectric kerosene oil

Rate of increase in MRR is observed high at a flushing pressure of 0.8 kg/cm², since a combination of current and large flushing force compels material removed from the EDMed surface to be thrown away from the hot zone area and subsequently produces new space for the eruption of material underneath the electrode. Hence material clearance and erosion is quite faster at high flushing pressures and current.

4.2 Effect of flushing pressure on TWR

Copper electrode with negative polarity was used as machining tool in present investigation. EDM studies have shown earlier that copper has minimum wear rate when machining is carried on aluminium based composites. But when current is increased, TWR is increased in parallel. Since at higher current thermal loading on both workpiece and copper electrode is increased which results in faster removal of material but also erodes the tool with same rate. Nevertheless, no major effect is observed on TWR with an increase in flushing pressure of dielectric kerosene oil. This can be attributed to rigidity of copper which is not affected by any dielectric pressure.

4.3 Effect of flushing pressure on SR

An increase in current result in larger volume of material being removed leading to bigger crater size and thus giving poor surface finish which is predominantly observed for lowest flushing pressure. On the other hand, surface quality is not much affected when flushing pressure is highest even at higher current values. A low flushing pressure gives comparatively lower force to material being removed from the machined surface and allows current to dominate which wears away material in large fractions. While a high flushing pressure provides a larger force to material being erupted from the machined surface and simultaneously effect of high current is normalized which removes material in small fractions. Therefore, a good surface quality is achieved at higher flushing pressures by retarding the effect of current.

5. Concluding remarks

The aim of present investigation was to evaluate the effect of dielectric flushing pressure on important EDM performance measures like MRR, TWR and SR being examined in majority of engineering alloys. 10wt.%Al_2O_3/AA2014 was fabricated via stir casting method and was latter machined by die-sinker EDM equipped with an external dielectric circulation system by varying flushing pressure at three levels. Flushing pressure during EDM significantly affects MRR and SR. No serious effect is observed on TWR. Surface quality improves when machining is done at higher flushing pressures. Also, large volume of material is removed at higher flushing pressures. MRR and SR are observed to behave inverse when flushing pressure is increased.

References

[1].Ramnath, B. Vijaya, et al. "Aluminium metal matrix composites-a review." Rev. Adv. Mater. Sci 38 (2014): 55-60.

[2].Kala, Himanshu, K. K. S. Mer, and Sandeep Kumar. "A Review on Mechanical and Tribological Behaviours of Stir Cast Aluminum Matrix Composites." Procedia Materials Science 6 (2014): 1951-1960.

[3].Kumar, Akshay, and Anubhav Singh Parihar. "A review on mechanical and tribological behaviours of stir cast copper–silicon carbide matrix composites." International Research Journal of Engineering and Technology 3.4 (2016): 2658-64.

[4].Anand, Ankush, et al. "Natural Systems and Tribology-Analogies and Lessons." Materials Today: Proceedings 4.4 (2017): 5228-5232.

[5].Rozenek, Marek, et al. "Electrical discharge machining characteristics of metal matrix composites." Journal of Materials Processing Technology 109.3 (2001): 367-370.

[6].Habib, Sameh S. "Study of the parameters in electrical discharge machining through response surface methodology approach." Applied Mathematical Modelling 33.12 (2009): 4397-4407.

[7].Singh, P. Narender, et al. "Electric discharge machining of Al–10% SiCP as-cast metal matrix composites." Journal of materials processing technology 155 (2004): 1653-1657.

[8]. Kumar, Sanjeev, et al. "Surface modification by electrical discharge machining: A review." Journal of Materials Processing Technology 209.8 (2009): 3675-3687.

[9]. Ho, K. H., and S. T. Newman. "State of the art electrical discharge machining (EDM)." International Journal of Machine Tools and Manufacture 43.13 (2003): 1287-1300.

[10]. Bayramoglu, M., and A. W. Duffill. "Manufacturing linear and circular contours using CNC EDM and frame type tools." International Journal of Machine Tools and Manufacture 35.8 (1995): 1125-1136.

[11]. Kunieda, Masanori, and Hideyuki Muto. "Development of multi-spark EDM." CIRP Annals Manufacturing Technology 49.1 (2000): 119-122.

[12]. Mohri, Naotake, et al. "Mirror-like finishing by EDM (multi divided electrode method)." Proceedings of the Twenty-Fifth International Machine Tool Design and Research Conference. Palgrave, London, 1985.

[13]. Kunieda, M., S. Furuoya, and N. Taniguchi. "Improvement of EDM efficiency by supplying oxygen gas into gap." CIRP Annals-Manufacturing Technology 40.1 (1991): 215-218.

[14]. Snoeys, R., F. Staelens, and W. Dekeyser. "Current trends in non-conventional machining techniques." Ann. CIRP 35.2 (1986): 467-480.

[15]. Staelens, Filip, and Jean-Pierre Kruth. "A computer integrated machining strategy for planetary EDM." CIRP Annals 38.1 (1989): 187-190.

[16]. Dauw, D., and R. Snoeys. "On the derivation and application of a real-time tool wear sensor in EDM." CIRP Annals-Manufacturing Technology 35.1 (1986): 111-116.

[17]. Tsai, H. C., B. H. Yan, and F. Y. Huang. "EDM performance of Cr/Cu-based composite electrodes." International Journal of Machine Tools and Manufacture 43.3 (2003): 245-252.

[18]. Gangadhar, A., M. S. Shunmugam, and P. K. Philip. "Surface modification in electro discharge processing with a powder compact tool electrode." Wear 143.1 (1991): 45-55.
[19]. Mohri, N., et al. "Metal surface modification by electrical discharge machining with composite electrode." CIRP Annals-Manufacturing Technology 42.1 (1993): 219-222.
[20]. Tsunekawa, Yoshiki, et al. "Surface modification of aluminium by electrical discharge alloying." Materials Science and Engineering: A 174.2 (1994): 193-198.
[21]. Simao, J., et al. "Workpiece surface modification using electrical discharge machining." International Journal of Machine Tools and Manufacture 43.2 (2003): 121-128.
[22]. Hassan, A. M. "An investigation into the surface characteristics of burnished cast Al Cu alloys." International Journal of Machine Tools and Manufacture 37.6 (1997): 813-821.