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A REVIEW ON ELECTRO DISCHARGE MACHINING OF METAL MATRIX COMPOSITE

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Abstract - The use of nonconventional machining techniques in cutting metal matrix composites (MMCs) has becomes useful for manufacturing of complicated shape die. Metal matrix composites are advanced materials having many properties such as high specific strength, good wear resistance, high toughness, high hardness and high thermal expansion coefficient. Electrical discharge machining is a best process to machine MMCs materials of complicated shapes. This current paper presents a survey of the research work done in electrical discharge machining (EDM) on MMCs. This review paper also implies that how the machining performance and process parameters are affected due to the percentage of reinforced abrasive particles in metal matrix composites and how to optimize the process parameter for optimizing the machining performance. The review is categorized in two parts the wire cut EDM of metal matrix composites and another is EDM of metal matrix composites materials .This literature review helps to identify the suitable process parameters and their ranges in machining of metal matrix composites.

Key Word s- MMC, TWR, WJM, LBM, Process Parameter, Composite Materials.

I. INTRODUCTION

Among the many unconventional processing techniques, EDM has proved itself to be one among the effective tool in shaping such difficult-to-machine materials. Electrical spark machining is used to make dies, punches and moulds. This process is used for producing automotive, aircraft and surgerical components [1]. Current, pulse on-time, pulse off time, gap voltage, feed and flushing pressure are widely used as a machining performance. Metal removal rate, tool wear rate, taper, radial overcut and surface roughness are considered as the machining performance. First EDM machine developed by Lazarenkos which is
used to erode very hard material such as tungsten or tungsten carbide. In the 1950's after new development this machine works on erosion phenomena [2-4]. This process can be employed to make complicated profiles on difficult to machine materials. Metal matrix composites (MMCs) have become important materials for the industrial because of their many properties such as high strength, low weight and high wear resistance. The manufacturing technology is one of the most important factors in the successful use of cutting methods; there occurs extreme tool wear due to the abrasive nature of reinforced particles. The formation sub-surface damages such as work-hardening of the matrix, delaminating between matrix and particle, and crack of particle or matrix were reported when machining MMCs at mild cutting condition. The current paper reports the electrical discharge machining of metal matrix composites.

II. PRINCIPAL OF OPERATION

Electrical Discharge Machining (EDM) process is one of the non conventional machining processes. When two current carrying wires come to contact with each other then spar is generated. If we see the contact point closely then we see that one wire lose its material and another one gain. In this process electro discharge machining process worked so it is also called spark erosion machine. In electro discharge machining process material remove by melting and vaporizing process. In this machining process there is no physical contact between tool and work piece so tool wear rate is small in compression to convectional machining process. Also it produces stress free surface. Schematic diagram of working of electro discharge machining is shown below.

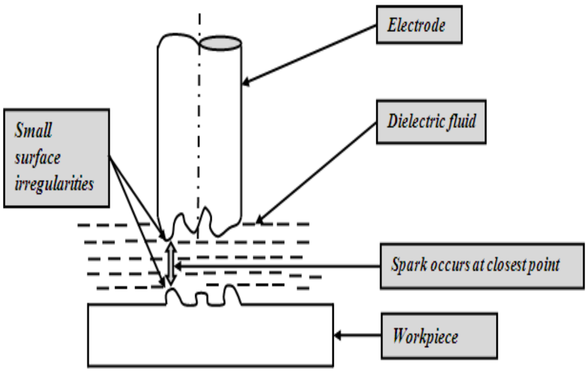

Fig- 1: Schematic diagram of EDM process [5]

III. LITERATURE REVIEW ON EDM OF MMC

Ramulu and Taya have been done their investigation for machinability of 15 vol. % and 25 vol. % SiC whisker/2124 aluminum matrix (SiC_w/Al) composites [6]. They were cut the material samples at coarse, medium, and fine conditions by using copper and brass tools. The experiment revealed that the material removal rate increases proportionally by increasing the power of electrode and MRR for 15 vol. % SiCw/2124 Al composites is more than the 25 vol. % SiCw/2124 Al composites. Copper electrode gives 5 to 10% more material removal rate in comparison to the brass electrode. Machining time is seen to be higher in 25 vol. % SiCw/Al than 15% SiCw/Al composite. It was also seen that higher cutting speed produces micro-damage in the surface and sub-surface area.

Jeswani investigated the effect of dielectric medium on the machining responses such as Material Removal Rate and Tool Wear Ratio in spark erosion machining process [7]. The result revealed that for electro discharge machining process by using high pulse energy range MRR becomes higher and TWR becomes lower when we used distilled water as compared to kerosene as dielectric medium.

Hung et al. in 1994 revealed in their investigation the usefulness of applying EDM operation for silicon carbide particles reinforced cast aluminum metal matrix composite [8]. Analytical models of the process were also developed to forecast the effect of process parameters on process responses such as metal removal rate, re-cast layer, and surface finish. In their research it was seen that the presence of SiC particles reduces the MRR. The reason behind it's that silicon carbide (SiC) particles act as a shielding medium for the aluminum matrix. The unmelted SiC particles withdraw together with the surrounding molten aluminum droplets from the composite material. While some aluminum droplets are flushed through the dielectric fluid and others trap the loosened SiC particles which re-solidify onto the surface of composite material then which produces a re-cast layer (RCL). The input power and current mainly controlled the MRR and thickness of recast layer and responsible for the surface finish of work piece..

Hocheng et al. had done their investigation on preliminary study of material removal rate of SiC/Al composite [9]. They were used Heat Conduction model to understand the correlation among the major machining parameters such as pulse duration, electrical current and crater size produced by single spark for the given material SiC/Al. Effect of single and continuous discharge on MRR were revealed. The investigation had been started from unit discharge and relationship between set discharge and crater size was developed. For calculating the crater size which is formed by a single discharge, two heat conduction approaches were used and their result was compared with the experimental data. The experimental data were very close with respect to the predicted data of the heat conduction model. The result shows that the MRR increases with increase of applied current and on time. The crater size which is produced by electro discharge machining in SiC/Al also compared with the crater size of steel and had been seen that crater size of steel is bigger in comparison to crater size of SiC/Al.
In continuous discharge analysis it was seen that MRR increases rapidly at the beginning and after that being retarted due to the presence of silicon carbide (SiC) particles in gap. This investigation recommends that for effecting machining of SiC/Al large current and short on time is required.

Hwa et al. [10] investigated wire electrical discharge machining of Al2O3p/6061Al composites materials. Their experiment showed the effect of pulse-on time on machining performance, cutting speed, the width of slit and surface roughness. The results implies that for avoiding the wire breakage in machining Al2O3p/6061Al composites, a very low wire tension, a high flushing rate and a high wire speed are required.

Seok et al.[11] investigation main aim is characteristic evaluation of (Al2O3)/ (CNTs) hybrid composites of micro-electrical discharge machining (EDM) process. They used catalytic chemical vapour deposition method to produce Alumina matrix composites reinforced with CNTs. Electrical conductivity of the materials and homogeneous distribution of CNTs in the matrix are important factors for micro-EDM of Al2O3/CNTs hybrid composites materials.

Prabu et al [12] conducted electrical discharge machining studies on Al-TiB2 with low-frequency vibrating tool. Their experimental result reveled that material removal rate and surface cracks of the work piece increases with an increase in current. The result shows that with increase in reinforcement ratio decreases the surface cracks and material removal rate.

Senthil [13] experiments perform a multi criteria optimization technique to optimize the electrical discharge machining parameter such as material removal rate, tool wear rate, surface roughness etc. in machining of Al-CuTiB2 in-situ metal matrix composites materials. Results shows that the discharge current, pulse on time and pulse off time are considered as machining parameter and material removal rate, tool wear rate and surface roughness are considered as response parameters. The experimental result analysis implies that, the optimized results are good agreement with confirmation run.

Mohan et al. were investigated on the machining of Al-SiC composite by using electro discharge machining [14]. The main aim of this research was to evaluate the effect of process parameter, volume percentage of SiC particles and electrode material on the machining performances. The process parameter which are consider in their experiment are electrode polarity, pulse duration (pulse on time, pulse off time) discharge current and electrode rotation. Al- 20% SIC and Al- 25 % SiC composites are taken as a work piece sample and copper and brass are selected as a tool material for the experiment. The research revealed that the material removal rate (MRR) is more with positive polarity and increases with increase in current. The MRR was found to be more with brass electrode (tool) as compared to the copper electrode (tool). On increasing of either the volume % of SiC particles in aluminium metal matrix composite (AMMC) or pulse duration decreases the material removal rate and the material removal rate increases with the increase of rotational speed of the electrode.
When the volume % of SiC particles in the AMMC is less, then the tool wear rate will be less and tool wear rate becomes more when pulse current is more. On decrease in the pulse current the surface roughness value becomes less and it becomes high with the increase of volume % of SiC particles in the aluminium metal matrix composite (AMMC). The research optimized the process parameter for different electrode and volume % of SiC particles in the AMMC for achieving maximum material removal rate.

IV. LITERATURE SURVEY ON WIRE-EDM OF MMCS

Ganpatrao et al. [15] investigate the study on WEDM of alumina particulate-reinforced aluminium matrix composites materials. They used Taguchi orthogonal array methodology to determined the effect of combination of reinforcement, current, pulse on-time, off-time, servo reference voltage and maximum feed speed, wire speed, flushing pressure and wire tension on cutting speed, surface finish, and kerf width. The optimum machining parameter was obtained for surface finish, cutting speed, and kerf width separately.

Samy et al. [16] in their research work developed a mathematical modeling for wire electrical discharge machining (WEDM) of Aluminium-Silicon Carbide composites materials. They optimized WEDM machining performance such as the material removal rate (MRR), cutting speed and the surface roughness was developed. The process parameters considered are the pulse frequency, the average machining voltage, the work piece height, the kerf size and the effect of percentage volume fraction of SiC present in the Aluminium Silicon Carbide composite materials.

Ganpatrao et al. [17] research work main aimed to determination of material removal rate of WEDM of metal matrix composites using dimensional analysis methodology. They made semi-empirical model of MRR in WEDM based on thermo physical properties of the work piece materials and process parameter such as pulse-on time, average gap voltage. An empirical model based on response surface method (RSM) was developed.

Rozenek [18] investigates the electrical discharge machining characteristics of metal matrix composites materials. Their research work revealed the influence of discharge current, pulse-on time, pulse-off time and voltage on the machining feed rate and surface roughness during WEDM of metal matrix composite AlSi7Mg/SiC and AlSi7Mg/Al2O3. Their experimental result shows that maximum cutting speed of AlSi7Mg/SiC and AlSi7Mg/Al2O3 composites are obtained to be approximately 3 times and 6.5 times lower than the cutting speed of aluminium alloy.

Satish kumar et al. [19] investigates the study of wire electrical discharge machining (WEDM) characteristics of Al6063/SiCp composites materials. In their research work, the effect of WEDM process parameters such as pulse on time, pulse off time, gap voltage and wire feed on process parameter such as material removal rate and surface roughness in MMCs Al6063/SiCp are given. They used Regression equations methodology to developed and predict the output parameters for Al6063 and composites materials.

V. CONCLUSIONS

Maximum researchers used different type of mathematical model such as Heat Conduction Model, Linear Programming, and Regression Analysis, Response Surface Methodology etc. for optimizing the process parameter and measures response. But no research has been done to comprising all the mathematical model for analyzing the optimum and more efficient mathematical model. In future more research can be done in this area.
No research has been done on the basic EDM Circuitry i.e. which circuit is prefect or outstanding for the optimum process parameter and better machining performance.
No research work has been done in the field of Dry EDM also. Hence in future more research work can be done in the field of Dry EDM.
No research has been done on the basic EDM Circuitry i.e. which circuit is prefect or outstanding for the optimum process parameter and better machining performance.

VI. FUTURE SCOPE

In future much research can be done in Dry electro discharge machining process and also for comparative analysis of different methodology which is used for analyzing the process and machining parameter of electro discharge machining process. Very less research work also has been done on alloy material tools so in future many experiments can be performed by using the alloy tool.

REFERENCES

[1] Ho, K. H., & Newman, S. T. (2003). State of the art electrical discharge machining (EDM). *International Journal of Machine Tools and Manufacture*, *43*(13), 1287-1300.
[2] Germer, L. H., & Haworth, F. E. (1949). Erosion of electrical contacts on make. *Journal of Applied physics*, *20*(11), 1085-1109.
[3] Cobine, J. D., & Burger, E. E. (1955). Analysis of electrode phenomena in the high‐current arc. *Journal of Applied Physics*, *26*(7), 895-900.
[4] Zingerman, A. S. (1956). Effect of Thermal Conductivity upon the Electrical Erosion of Metals. *Soviet Physics-Technical Physics*, *1*, 1945-1958.
[5] 5Abulais, S. (2014). Current Research trends in Electric Discharge Machining (EDM). *International Journal of Scientific & Engineering Research*, *5*, 100-118.
[6] 6Ramulu, M., & Taya, M. (1989). EDM machinability of SiCw/Alcomposites. *Journal of materials science*, *24*(3), 1103-1108.
[7] Jeswani, M. L. (1981). Electrical discharge machining in distilled water. *Wear*, *72*(1), 81-88.
[8] Hung, N. P., Yang, L. J., & Leong, K. W. (1994). Electrical discharge machining of cast metal matrix composites. *Journal of materials processing technology*, *44*(3-4), 229-236.
[9] Hocheng, H., Lei, W. T., & Hsu, H. S. (1997). Preliminary study of material removal in electrical-discharge machining of SiC/Al. *Journal of Materials Processing Technology*, *63*(1-3), 813-818.
[10] Yan, B. H., Wang, C. C., Chow, H. M., & Lin, Y. C. (2000). Feasibility study of rotary electrical discharge machining with ball burnishing for Al2O3/6061Al composite. *International Journal of Machine Tools and Manufacture*, *40*(10), 1403-1421.

[11] Hyun-Seok, T. A. K., Chang-Seung, H. A., Ho-Jun, L. E. E., Hyung-Woo, L. E. E., Jeong, Y. K., & Myung-Chang, K. A. N. G. (2011). Characteristic evaluation of Al2O3/CNTs hybrid materials for micro-electrical discharge machining. *Transactions of Nonferrous Metals Society of China*, *21*, s28-s32.

[12] Prabu, M., Ramadoss, G., Narendersingh, P., Christy, T. V., & Eswaran, V. V. (2014). Electrical discharge machining of Al-TiB2 with a low-frequency vibrating tool. *Science and Engineering of Composite Materials*, *21*(3), 445-452.

[13] Senthil, P., Vinodh, S., & Singh, A. K. (2014). Parametric optimisation of EDM on Al-Cu/TiB2 in-situ metal matrix composites using TOPSIS method. *International Journal of Machining and Machinability of Materials*, *16*(1), 80-94.

[14] Mohan, B., Rajadurai, A., & Satyanarayana, K. G. (2002). Effect of SiC and rotation of electrode on electric discharge machining of Al–SiC composite. *Journal of Materials Processing Technology*, *124*(3), 297-304.

[15] Patil, N. G., & Brahmankar, P. K. (2010). Some studies into wire electro-discharge machining of alumina particulate-reinforced aluminum matrix composites. *The International Journal of Advanced Manufacturing Technology*, *48*(5-8), 537-555.

[16] Ebeid, S., Fahmy, R., & Habib, S. (2004). Mathematical Modelling for Wire Electrical Discharge Machining of Aluminum-Silicon Carbide Composites. In *Proceedings of the 34th International MATADOR Conference* (pp. 147-152). Springer, London.

[17] Patil, N. G., & Brahmankar, P. K. (2010). Determination of material removal rate in wire electro-discharge machining of metal matrix composites using dimensional analysis. *The International Journal of Advanced Manufacturing Technology*, *51*(5-8), 599-610.

[18] Rozenek, M., Kozak, J., Dabrowski, L., & Łubkowski, K. (2001). Electrical discharge machining characteristics of metal matrix composites. *Journal of Materials Processing Technology*, *109*(3), 367-370.

[19] Satishkumar, D., Kanthababu, M., Vajjiravelu, V., Anburaj, R., Sundarrajan, N. T., & Arul, H. (2011). Investigation of wire electrical discharge machining characteristics of Al6063/SiC p composites. *The International Journal of Advanced Manufacturing Technology*, *56*(9-12), 975-986.

