REVIEW OF RESEARCH WORK IN WIRE CUT ELECTRO-DISCHARGE MACHINING ON METAL MATRIX COMPOSITE MATERIALS

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Abstract: ***Non-traditional process like wire electro-discharge machining (WEDM) is found to show a promise for machining metal matrix composites. Metal matrix composites (MMCs) are newly Advanced materials having the properties of light weight, high specific strength, and good wear resistance and a low thermal expansion coefficient. These materials are extensively used in Industries like. The paper presents a review of EDM process and year wise research work done in EDM on MMCs. The paper also discusses the future trend of research work in the same area.***

Keywords: WEDM, Metal Matrix Composites, Process Parameters

I. INTRODUCTION

In 1770, Joseph Priestly, a British scientist first discovered the erosive effect of electrical discharge. In 1943, soviet scientists B. Lazarenko and N. Lazarenko had exploited the destructive effect of an electrical discharge and developed a controlled process for machining material that are conductors of electrically. In Wire EDM process a thin metallic wire is fed onto the work piece, which is submerged in a tank of dielectric fluid such as de-ionized water.

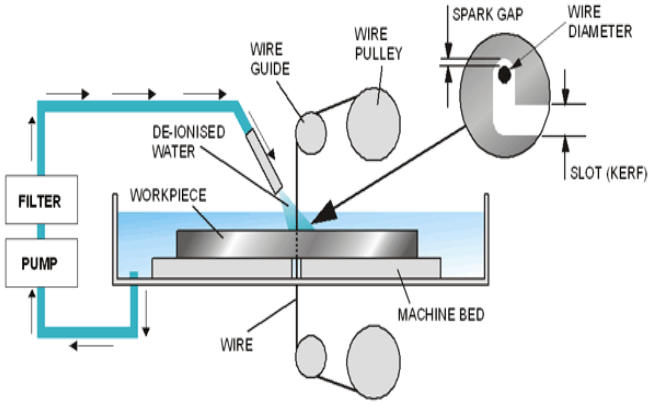

Fig.1: General features of WEDM process

Working Principle of WEDM process

The working principle of WEDM process is based on the thermoelectric energy. This energy is created between a work piece and electrode submerged in a dielectric fluid with the passage of electric current. The work piece and the electrode are separated by a specific small gap called spark gap. Pulse arc discharges occur in this gap filled with an insulating medium preferably a dielectric liquid. Material is removed from the work piece through localized melting and vaporization of material.

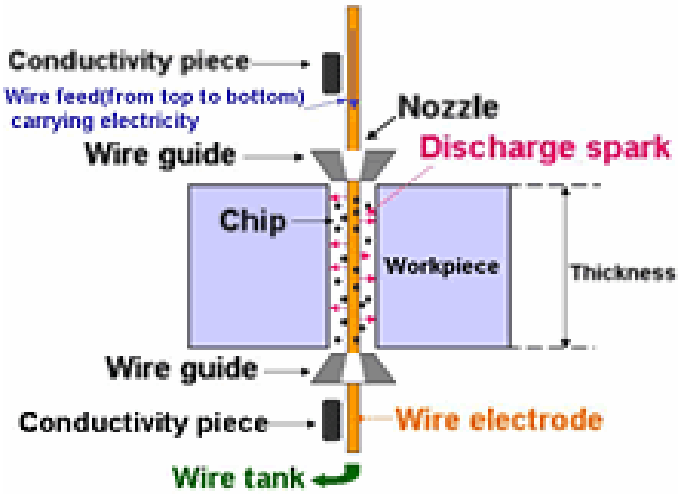

Fig.2: Basic principle of WEDM process

Process parameters of WEDM

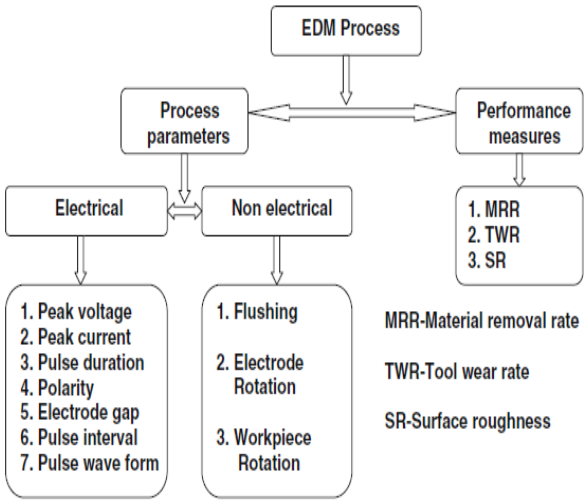

Fig.3: Process parameters and performance measures of EDM Process

II. RESEARCH IN WIRE CUT EDM ON METAL MATRIX COMPOSITES

Kamal Kumar Jangra,(2014)[1], focus on experimental study for multi pass cutting (single rough cut followed by multi trim cuts) operation in WEDM of WC 5.3% Co composites. Using Taguchi's method to investigate the influence of rough cut history (RHis), discharge current(Ip), pulse on time (Ton), wire offset(WO) and number of trim cuts(Ntrim) on two performance characteristics namely depth of material removed (DMR) and surface roughness(SR). Results shows

that using single trim cut with low discharge energy and optimal wire off set values, surface roughness can be improved successfully. But multi trim cuts at low discharge energy are required to obtain the nominal value of DMR in order to eliminate the recast layer and heat affected zone developed in rough cutting operation. Parameters setting (Ip 70; Ton 105; WO 130 and Ntrim 2) provide the nominal value of DMR 39 µm and low SR 0.89 µm, these are the optimal setting for trim cutting operation. Using optimal value of depth of material removed in trim cutting operation, wire offset has been predicted for rough cutting operation which helps to achieve the final dimensional precision. A technological data has been provided for machining of WC-5.3% Cobalt composites on WEDM that would be very helpful for tool manufacturer and manufacturing engineers. By using same method of selection of accurate wire offset and discharge parameters for rough and trims cutting operations can be solved easily for WEDM of new and exotic materials in order to achieve highest machining performance.

Fig.4: Measurement of surface roughness[1]

ThellaBabuRao, A. Gopala Krishna,(2014)[2], works onselection of optimal process parameters in WEDM for aluminum meta matrix composites like Al7075/SiCp. Conduct machining experiments, surface roughness, metal removal rate, and wire wear ration are considers responses to evaluate the WEDM performance. RSM, ANOVA, Non Dominated Sorting Genetic Algorithm-II, and SEM used for different output parameters. The research work determines the optimal machining parameters to achieve high production rate and good surface quality. Response surface methodology was used to model the responses of surface roughness (Ra), MRR, and WWR in terms of the chosen process variables. The problem was formulated as a multi – constraint multi objective optimization problem to minimize MRR, and minimize WWR simultaneously. Most effectively used evolutionary algorithm NSGA-II was simulated to solve the formulated optimization problem. The resulted optimal solutions were also analyzed using SEM examinations. SEM examinations of machined surface and wire wear obtain results. The finest surface quality SEM image of the sample with Ra=0.76 micro-m, MMR=0.021 g/min, WWR=0.007 where in the roughest surface quality SEM image of the sample with Ra=3.64 micro-m, MMR=0.068 g/min, WWR=0.119.

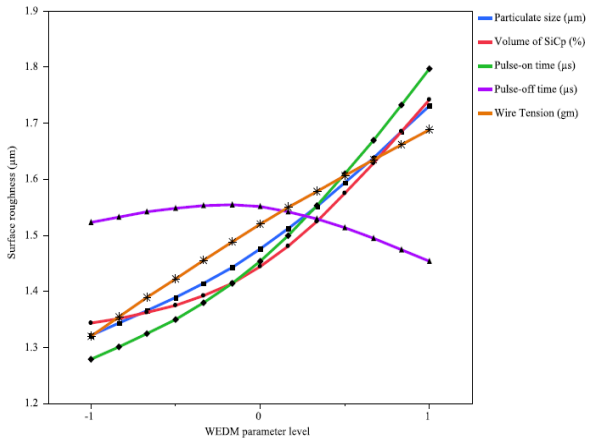

Fig.5: Main effect of WEDM paraameters on metal removal rate[2]

Manish Kumar, Alkesh Manna, S.K. Mangal and AnupMaulik, (2014)[3],This paper reflects the various parameters of WEDM on material removal rate (MRR) and surface finish during machining of Al/Sic MMC. Using Taguchi method develops mathematical models for different response characteristics are developed to investigate the influence of cutting parameters during machining. The work piece samples fabricated through liquid stir casting process. Samples of different sizes Al/10 wt. % SiC. Taguchi robust design a L_{18} (2^1 X 3^7) mixed orthogonal array is employed for the experimentation. Taken cutting parameters are Ton, Toff, Peak current, wire feed, and wire tension. Result shows the Pulse on time (Ton) and pulse off time (Toff) are the most significant and significant machining parameters for controlling the metal removal rate (MRR). Pulse on time (Ton) and pulse off time (Toff) are the most significant and significant machining parameters, respectively for the surface roughness height (Ra, µm). The developed mathematical models for MRR and surface roughness height, R_a, are successfully proposed for proper selection of machining parameters and for evolution of surface roughness values and MRR under various combinations.

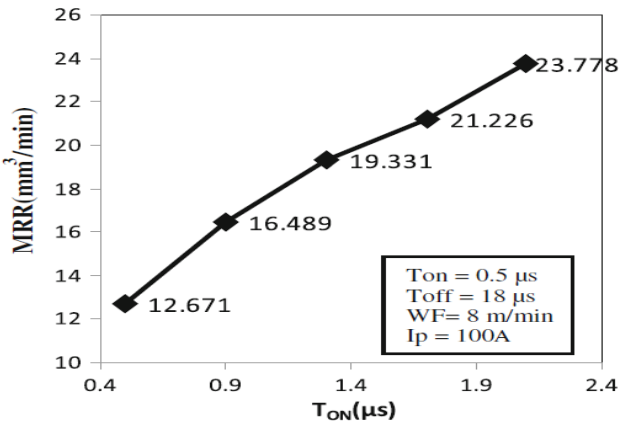

Fig.6: Effect of T_{ON} on MRR [3]

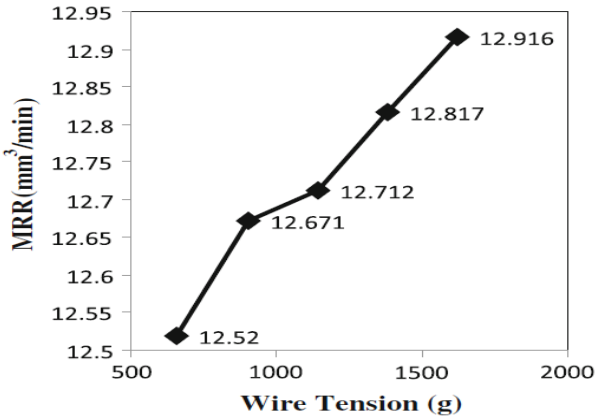

Fig.7: Effect of wire tension on MRR[3]

Kamal Jangra, Sandip Grover, AmanAggarwal,(2012)[4], this research concentrated on intricate machining of WC-5.3% Co composite on WEDM. Taguchi's design of experiments uses to investigate the process parameters for four machining characteristics namely material removal rate, surface roughness, angular error and radial over cut (RoC). Using Analysis of Variance (ANOVA) on gray relation grade (GRA), significant parameters affecting the multi machining characteristic has been determined. The six input parameters namely taper angle (A), peak current (B), pulse on time (C), pulse off time (D), wire tension (E) and dielectric flow rate (F), and L18 orthogonal array has been adopted to conduct the experiments. ANOVA on observed machining characteristics shows that three process parameters namely taper angle, pulse on time and pulse off time are most significant affecting the MRR and SR both. In case of angular error, taper angle, peak current and dielectric flow rate has been found most significant parameters while in RoC (radial overcut), taper angle, peak current and pulse on time are most significant.

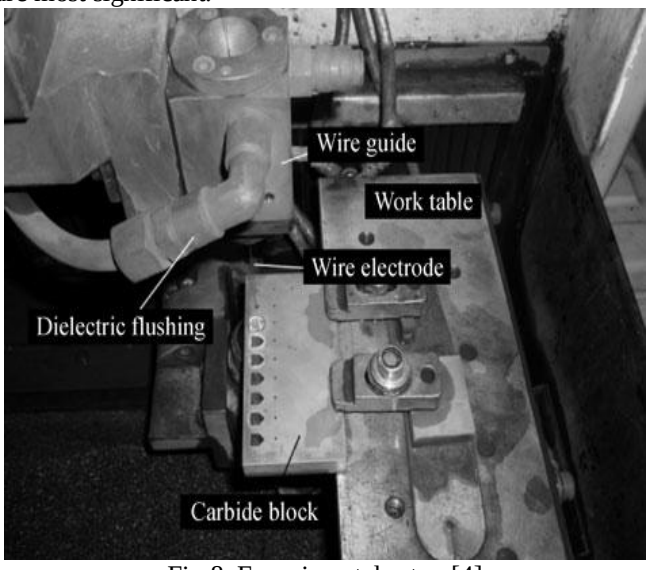

Fig.8: Experimental setup [4]

Nilesh Ganpatrao Patil, P. K. Brahmankar,(2010)[5],works on determination of material removal rate in wire electro discharge machining of metal matrix composites using dimensional analysis and develop model using non-linear estimation technique such as quasi-Newton and simplex. The work material was silicon carbide particulate reinforced aluminum matrix composites and plain brass wire (CuZn37) was the electrode of 0.25 mm diameter. The Experiments did on three different materials namely Al/SiCp/10%, Al/SiCp/20% andAl/SiCp/30%, by fixing machining parameters like work piece height, length of cut, angle of cut, location of the work piece on the table, temporary reduction in frequency, pulse off time, wire speed, wire tension, pulse on time, average gap voltage, wire electrode and dielectric. The experimental results show that increased percentage of ceramic particulars in MMC causes decreased MMR. The decreased in MRR is almost 12% with an increase of 10% in ceramic reinforcements.

Probir Saha, Abhijit Singha, Surjya K. Pal, Partha Saha,(2008)[6],focused experiment on soft computing based prediction of cutting speed and surface roughness in WEDM with material of tungsten carbide cobalt composite. In study with Multi-variable regression analysis and Back-propagation neural network (BPNN) model have been developed to correlate the in process parameters, such as pulse on time, pulse off time, peak current, and capacitance and output parameters measures namely cutting speed and surface roughness. The proposed neural network model and regression model for this process can exhibit the parametric effect on cutting speed and surface roughness. It is also seen that increase in both peak current and capacitance lead to the increment of cutting speed and surface roughness. The SEM analysis conforms that machined surface is characterized by loosely bounded WC grains, and a lot of micro cracks, which are radially spread over the machined surface. It is also observed that at high energy level, the size of the micro cracks increases.

III. DISCUSSION AND FUTURE TRENDS

After study of research papers on metal matrix composites, the following conclusions can be drawn. Most of the work belongs to SiC reinforced metal matrix composites. Not so much work is reported other MMCs like cobalt matrix with hard tungsten carbide particles, steel reinforced with boron nitride, Aluminum boron carbide matrix etc. Many MMCs are yet to be explored for suitable electrode material and electrode design so this area is still open for research. Most of the work done on MMR and surface roughness , so more research work still required to study the mechanical properties of metals and suitable wire material during WEDM.

IV. SUMMARY

A review of research work on MMCs, in every research paper the objectives are the same: to enhance the capability of good machining performance to get better output product by using suitable process parameters and to have better working conditions.

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