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Effect of WEDM Machining Parameter on the MMC: A Review

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Abstract

Recent area of manufacturing is highly focus on good accuracy and a complex shapes are mechanized by the advanced machining operation. The wire electrical discharge machining (WEDM) have the ability to produce the complex shapes with having high accuracy. The WEDM is non-contact type machining operation and is used for metal materials as well as Metal Matrix Composites (MMCs), ceramics composites those have many application in vast areas such as defence, aircraft, automobile sector, medical equipment's, agriculture machines, etc. As the requirement of metal properties such as light weight, good wear resistance, low density, high strength which can be possible due to combinations of two or more materials and this materials called as Metal matrix composites. The Aluminium is widely used as a base metal in MMCs along with varying reinforcement particles such as B4C, Al_2O_3, TiO_2, ZrO_2, SiC. The most of the researchers are studied on the WEDM parameters, process modelling, electrode materials, dielectric medium, etc. The considerable input parameter is the focusing area for improved Material Removal Rate, Surface Roughness and Kerf-width of composite. For a more thorough comprehension of the research conducted in this field, the diversity of studies must be categorized. This study analyzes the processing of MMCs, including the approaches taken, the results and a summary of the review. The future directions of the same field's study are also discussed in the paper.

Keywords: WEDM, AlMMC, Reinforcement, composites

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INTRODUCTION

As per the todays trends in manufacturing the requirement of material is having some properties such as light in weight, high corrosion resistance, high strength, low thermal expansion ratio and low density so such kind of properties in single conventional materials is not available. For the fulfillment of such requirement the novel material must have to be produce [1, 2]. The Metal matrix composite is the formation of novel material by the adding the reinforcement in the base material in varying percentage for enhancing the properties of conventional materials. The composite means the combination of two or more different materials which having the special add-on properties who helps to produce the required or defined material for the required application. Aluminium based hybrid composite are satisfying the manufacturing market demand which have the potential to fulfill

the required properties [3–5]. M. O. Bodunrin et al said that mechanical and tribological properties of AMCs shows the improved by reinforcing the ceramics as compared to unreinforced alloys. The effect of composite in the double synthetic reinforcement is better than the single reinforcement. He also defined the agro based and industrial based waste material can be used as a reinforcement which shows the improvement in the performance and also reduction in the cost of composites [6]. V. Kavimani et al. investigate on Magnesium MMC and examined machining parameters of WEDM on the MRR and Ra. For experimentation the considered parameters for materials are two i.e. wt% of SiC and three of WEDM i.e. P-ON, P-Off and WFD. The Taguchi coupled GRA results was shows that the increasing the P-ON and WFD reflects the improvement in MRR and by increasing in MRR the surface roughness decreases [7]. The Mica and SiC composite was prepared by using the stir casting technique for the investigation of mechanical and wear properties of novel composite. The scanning electron microscopic structure is shown good bonding in the microstructure and the various mechanical testing such as tensile test, hardness test and wear test were conducted on the samples. Result indicates the enhancement in strength and hardness of Al/10SiC-3mica as well as effect of Mica reinforcement reflects the less in wear loss [8]. A specific thermal non-contact machining method is wire electrical discharge machining (WEDM). The WEDM method has emerged over the past ten years as a competitive and cost-effective machining solution that can handle the machining demands from a simple tool to a complicated die forming process. When cutting complicated shapes with extreme precision for MMCs, Wire Electrical Discharge Machining (WEDM) exhibits greater capability. Due to their higher hardness and presence of abrasive reinforcing particles, MMCs present a major risk for tool wear during conventional machining.

Many common machining techniques, including turning, Slotting, milling etc., may be used to manufacture MMCs. However, the results demonstrate that MMCs cannot be machined using traditional manufacturing methods due to high tool wear, poor machinability, poor surface quality, low precision, and the need for additional cutting force. Therefore, the majority of authors suggested non-conventional machining procedures for the machining of MMCs. Following Table contains a collection of the most recent reviews. The Table 1 summarizes the authors' study on several MMC kinds, the methods they employed, their reactions, and their key discoveries, which open up new research opportunities [9].

Table 1. Authors' study on several MMC kinds

S.N.	Author	MMC	Techniques used	Responses	Findings
1	Prashantha et. al. (2017) [10]	Al6061 reinforced with 36 µ size SiC	DOE by L9 orthogonal array	Material Removal Rate by using WEDM machining	Increase in %vol of SiC particles reflects decreasing MRR
2	H. Majumder et. al. (2018) [11]	Titanium grade 6	Taguchi's L27 Orthogonal array with GRNN and MRA models used	MRR, Surface Roughness and kerf width	The GRNN model is reflects good result as compared to MRA model.
3	Mangesh Phate et al (2020) [12]	Al/SiCp MMC 15–20% silicate used	Experimentation by Taguchi L18 & Multi response optimization by PCA and ANN	Roughness of part (Ra), material removal rate and kerf width	Optimum value gets on 15% of SiC,112 µs P-ON, 56 µs P-OFF,4 mm/sec WFR, 3 knob position of Ip, 4 kg WT and 13 kg/m^3 dielectric liquid pressure
4	V. Kavimani 1 et al. (2019) [7]	SiC Nano particles doped with varying % with r-GO using hydrothermal reaction (Magnesium Based MMC)	DOE by Taguchi and Analysis by GRA and PCA for multi objective optimization	MRR, Ra by using WEDM machine	Powder metallurgy process is suitable for composite preparation. T-On and wt % of reinforcement importatnt parameter for MRR. T-OFF and increasing wt % of reinforcement shows important role in Ra.

					Optimal values received by GRA and PCA method.
5	Adeel Ikram et al (2013) [13]	Tool Steel D2	Taguchi L18 orthogonal array for DOE. ANOVA & Signal to noise (S/N) ratio for statistical analyses. Linear regression & additive models are additionally developed.	Surface roughness (Ra), kerf width & material removal rate	Pulse on Time & Ip is lowest which reflects on good Ra but opposite in MRR which have more value to increase the MRR. For achieving minimum kerf material thickness, PON time and WFR should be at low level.
6	Sachin Ashok Sonawane et al. (2018) [14]	Nimonic-75 alloy	DOE by Taguchi's L27 orthogonal array and PCA for optimization of parameters	MRR, Ra Overcut by using WEDM	Pulse On-Time is highly influencing affecting parameter found by ANOVA on the outputs. SEM shows the micro-cracks, large crater sized, lump debris and matt surface look at high energy level discharge.
7	R. N. Ahmad et al. (2010) [15]	AMC reinforced 5% of Al2O3	DOE by Taguchi's and Regression analysis, Mathematical models are done	MRR	Servo voltage influenced the MRR, SV is less then mean gap is narrow which increases the electric sparks number due to that MRR is increases.
8	M. Ravikumar1 et al. [16]	Al7075 hybrid MMC reinforced by alumina (2, 4, and 6 wt.% of Al_2O_3) and silicon carbide (3, 6, and 9 wt.% of SiC)	Taguchi's L27 Orthogonal array	Mechanical Properties and wear Loss	ANOVA shows Al_2O_3 is considerable factor that impacted the hardness as well as wear loss of composites followed by SiCp and heat treatment. The wt. % increases of reinforcement which reflects in the Mechanical properties and by higher the aging temperature the wear resistance and hardness properties are increased.

SUMMARY OF LITERATURE REVIEW

As per the literature it has been seen that the effect of PON-Time, Pulse-OFF Time and Input Current is highly effecting parameter which reflects on Material Removal Rate, Surface Roughness and kerf width. Along with it the many researchers considered other parameters such as Wire Feed Rate, Servo Voltage, wire tension, Material of wire, etc. these are less effect as compared to it. The graphs shows the influencing effects of machine parameters. The selection of electrode/cutting wire material is the prime requirement due to only electrically conductive materials to be mechanized as well as lower wear of electrode. Mostly zinc, copper, graphite, tungsten, brass and silver materials used for wire electrical discharge machining. Many researchers widely used Copper and Zinc coated wire due to improved cutting speed. In environment of oxygen zinc coated wire is experienced the secondary heat treatment procedure as well as cost of zinc wire is less as compared to copper wire. The literature shows the wire dimension is mostly used 0.25 mm [10, 11, 12, and 15].

The Figure 1 shows the effect of Pulse ON Time is highly impact on the Material Removal rate. The effect of Boron carbide i.e. reinforced particles also reflects the reduction in the MRR as well as

the effect of Al_2O_3 shows that there is less effects on MRR. While experimentation the increasing the Current this improvement in MRR but due to high current and PON-Time the surface roughness of the component highly affected [17].

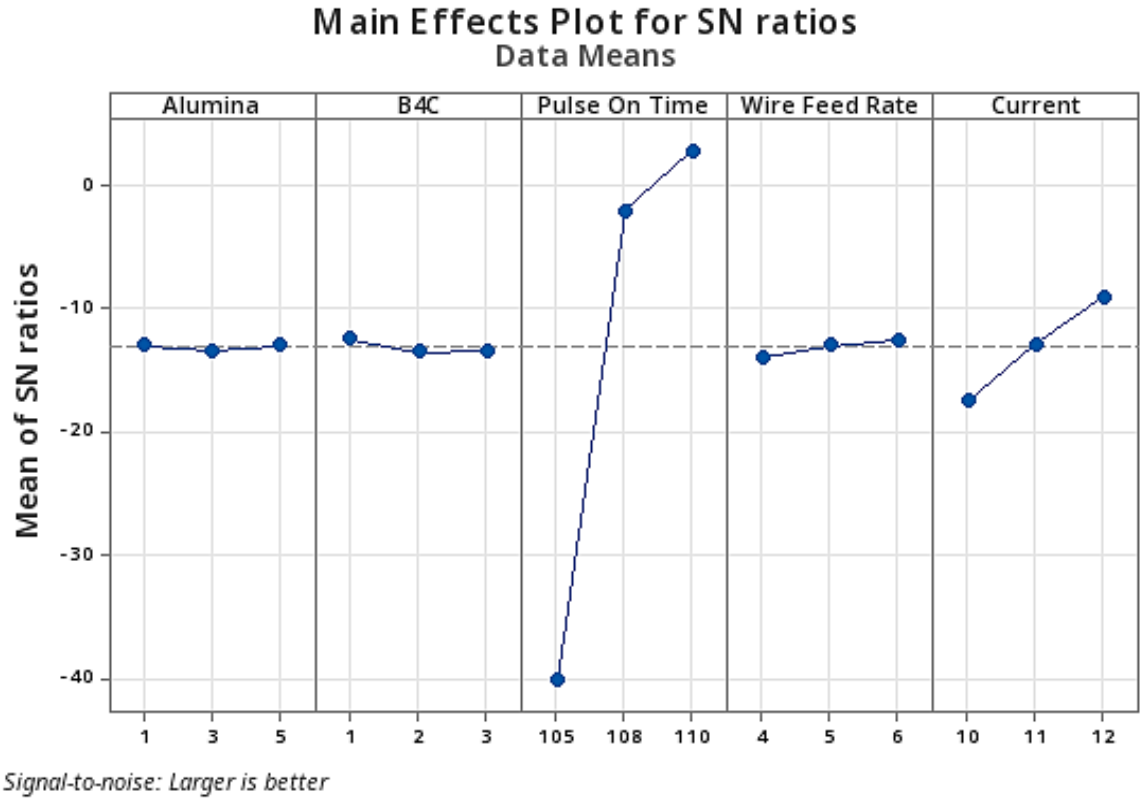

Figure 1. Effect of Input Parameter on MRR by Plot SN ratios.

The Effect of Reinforcement which reflects on the Surface roughness due to that Ra value increased. As per literature, while keeps the Pulse ON Time is at low level with combination of lower current as a input parameters the surface roughness show the better results but by increasing the pulse on time along with current the value of Ra goes on increases. In Many experimentation shows that the MRR and Ra are inversely proportional, so while studying the levels of considerable parameters of PON and Current should be maintain the both MRR and Ra. The Figure 2 shows the effect of input parameters and reinforced particles on the Surface Roughness. In this graph Pulse ON Time, B4C and wire feed rate is highly impacted on Ra value. Due to high pulse on time and wire feed rate the wire breakage problem is occurred it reflects the Ra value increased. As per the graphs the range of PON-Time and Wire feed rate keeps minimum which shows better results. The breakage of wire is happened due to formation of nodules on wire while machining carried out, for the better performance maintain the wire feed rate as per the other parameters such as pulse on time, current, pulse off time and machining speed [12, 14].

Kerf width is the mainly focused due to dimensional accuracy of component, the voltage formation in between the wire and material, the spark is generated due to that cutting operation is carried out. The Kerf width highly influenced by the many parameters such as PON-Time, Current and reinforced particles as well as dielectric medium which used. The literature shows that the kerf width is directly proportional to MRR and inversely proportional to surface roughness. The value of kerf width is minimum is better. As per the varying materials as well as machining parametric values the kerf width values gets changed such as for Titanium reinforced particle the minimum kerf width 0.356 mm at TON-3 µs, Gap voltage–40 V, Toff-10 µs and wf–1 m.min calculated by Tigabu Abebe [18]. Figure 3 shows Effect of Input Parameter on Kerf-width by Plot SN ratios.

Figure 2. Effect of Input Parameter on Surface Roughness by Plot SN ratios.

Figure 3. Effect of Input Parameter on Kerf-width by Plot SN ratios.

Most of the study on Metal matrix composite is carried out which shows the highly influenced the mechanical properties of conventional materials by adding the reinforcement. The Aluminium based

MMC is mostly preferable by the researchers due to light in weight as well less in corrosion. For the preparation of MMC stir casting technique is mostly preferably followed due to homogeneous mixture formation. The nonconventional method used for the machining operation which is Wire EDM/EDM was used due to higher in accuracy and complex shape preparation. In the WEDM the influencing parameter is suggested by the researchers are PON-Time, POFF-Time Input Current, Wire Feed Rate and Wire Tension. The composite size is not shown considerable effect on the output parameters. As per the literature high PON-Time and Input Current/Servo Voltage is reflects on improved material removal rate and lower in the Surface roughness.

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