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EXPERIMENTAL INVESTIGATION DURING WIRE ELECTRIC DISCHARGE CUTTING OF SICP/6061 ALUMINUM METAL MATRIX COMPOSITE

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Abstract: *Aluminum metal matrix composite is a kind of difficult to machine material. In general, it is inefficient if conventional methods are used to machine it, with worse surface quality and serious wear of the cutting tool. In this paper, an attempt is made to machine the 6061 aluminum metal matrix composite (MMC) reinforced with silicon carbide particulates (i.e. SiC_p/6061 Al) using wire electric discharge machining (WEDM). Wire electric discharge cutting (WEDC) parameters namely servo voltage (SV) and pulse-on time (T_{ON}) were varied to study their effect on the quality of cut in SiC_p/6061 aluminum MMC using average cutting rate and microstructure of the cut surface as response parameters. The characteristics of the surface produced by WEDC were analyzed by scanning electron microscope (SEM).*

Key words: *Wire electric discharge cutting (WEDC), Metal matrix composite (MMC), Average cutting speed, Microstructure*

1. INTRODUCTION

MMCs have become increasingly important in modern industrial applications due to their properties such as high strength-to-weight ratio, high toughness, lower value of coefficient of thermal expansion, good wear resistance, and capability of operating at elevated temperature [Miracle D.B. (2005); Taha M.A. (2001)]. Using traditional machining processes to machine hard composite materials causes very high tool wear due to abrasive nature of reinforcing particles [Yan B.H. & Wang C.C. (1993)] thus shortening the cutting tool life. Although, nontraditional machining techniques such as water jet machining (WJM) and laser beam machining (LBM) have been used in past [Muller F. et. al. (2000); Grabowski A. et. al. (2006)] but their machining equipment is expensive and height of the workpiece is a constraint in using these processes. In this context, wire electric discharge machining (WEDM) seems to be a better choice for machining the MMCs because it offers easy control and has capability of machining intricate complex shapes WEDM is a type of thermal advanced machining process capable of accurately machining the parts having varying hardness, complex shapes and sharp edges that are difficult to machine by other traditional and nontraditional machining processes. Lot of research work has been on WEDM but, very few investigations on WEDM of MMC have been done [Patil N.G. et. al. (2006); Saha P. et. al. (2009)] and particularly there is lack of published literature on WEDM of Al-based MMCs. This paper presents the experimental findings on the wire electric discharge cutting (WEDC) of 6061 aluminum MMC reinforced with silicon carbide particulates (i.e. SiCp/6061 Al). In the present work effect of servo voltage (*SV*) and pulse-on time (T_{ON}) on the quality of cut in terms of average cutting speed and microstructure of the cut surface has been evaluated to bracket range of input parameters for carrying out further research on WEDC of SiCp/6061 aluminum MMC.

2. EXPERIMENTATION

In this experiment, three types of 6061 aluminum based MMCs made by stir casting and having 5%, 7.5% and 10% SiC particles (by weight) as reinforcement were used as the workpieces. The workpieces were of rectangular shape having a thickness of 6 mm. Table 1 shows the chemical compositions of the matrix of the MMCs used in this study.

Si	0.4-0.8
Fe	0.7 max
Cu	0.15-0.40
Mn	0.15 max
Mg	0.8-1.2
Cr	0.04-0.35
Zn	0.25 max
Ti	0.15 max
Other elements	0.15 total, 0.05 max each
Al	REM

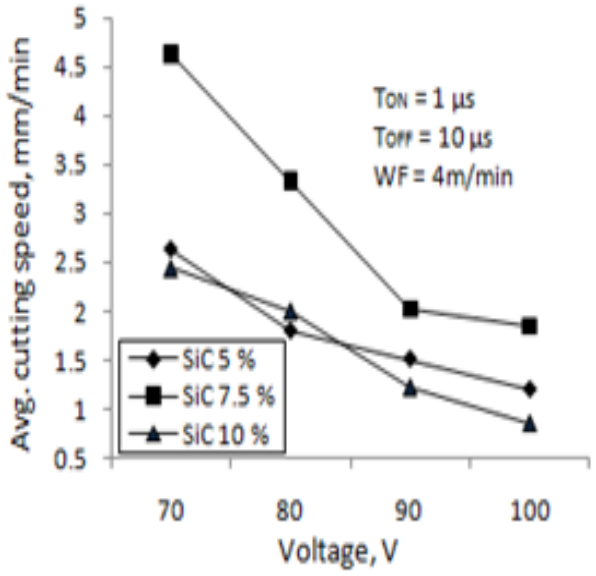
Tab. 1 Chemical composition of Al6061 alloy

The experiments were conducted on the ECOCUT WEDM Machine from Electronica India Pvt Ltd. A diffused brass wire of 0.25 mm diameter was used as the cutting tool. The deionized water was used as dielectric. The input parameters were varied during the experiments namely servo voltage (*SV*) in the range of 70-100 V, and pulse-on time (T_{ON}) in the range of 1-10 µs to study their effects on the average cutting speed and microstructure of the cut surface. The experiments were conducted using one-factor-at-a-time experiment strategy in which only one input parameter was varied while all others input parameters were kept constant at the middle point of their respective range. Average cutting speed was calculated by dividing the length of cut by the total cutting time which was recorded using a stop watch having a least count of 0.01 seconds while, the microstructure of the cut surface was examined using SEM.

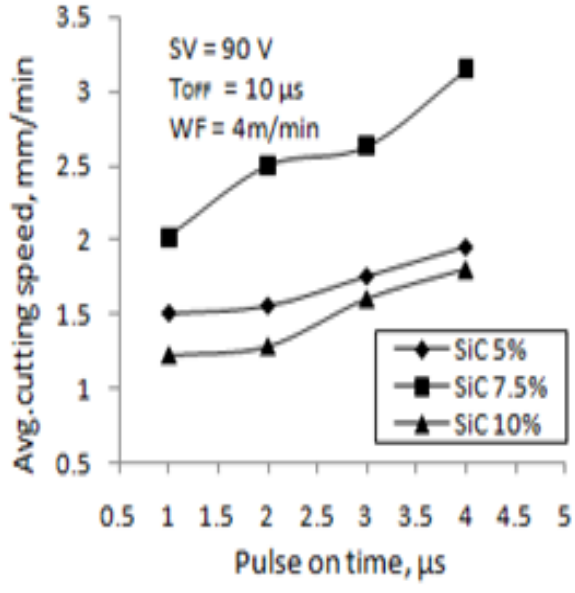
3. EXPERIMENTAL RESULTS AND ANALYSIS

Machining characteristics. Fig. 1(a) shows the effect of voltage on the average cutting speed indicating that as the average cutting speed decreases continuously with increase in the voltage for all three MMCs and that at any value of the voltage, the average cutting speed is maximum for the MMC with 7.5% SiC_p. The frequency of wire breakage increases significantly when the voltage reaches less than 70 V. Fig. 1(b) depicts the variation of the average cutting speed with the pulse-on time indicating that the average cutting speed increases continuously with increase in the pulse-on time for all three percentage of

SiC_p and its value being highest for the MMC with 7.5% SiC_p at any value of the pulse-on time. Surface Morphology. SEM of the cut surface by WEDC was conducted to evaluate the effect of machining parameters on the surface textures of the 6061 Al based MMC reinforced with 7.5% SiC particles. Figs 2 (a)-(d) show the SEM images of the cut surfaces for the end values of the bracketed input parameters (i.e. voltage at 70 and 90 V; and T_{ON} 1 and 4 µs). It is clear that the morphology of the WEDC surface was dependent on the applied voltage and pulse-on time. The WEDC surface abounds with the craters and ridged surface. The craters and ridge-rich surface were formed by the melted material. When lower voltages (Fig. 2(a)), lower pulse-on time (Fig. 2(c)) are used, the surface characteristics had minor hillocks and valley. When the voltage and pulse-on time increases the cut surface exhibits deeper craters and ridge-rich surfaces.



a



b

Fig. 1. Effect of (a) servo voltage; (b) pulse-on time; on the average cutting speed

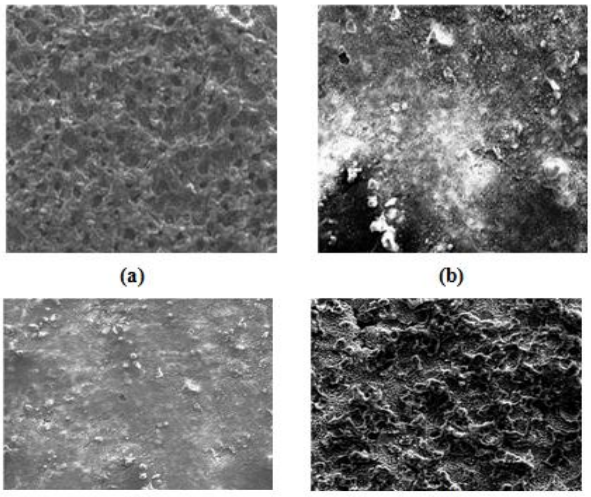


Fig. 2. SEM micrograph of SiCp/6061 aluminum MMC after WEDC at (a) servo voltage 70 V; (b) servo voltage 90 V; (c) pulse-on time of 1 µs; (d) pulse-on time of 4 µs;

4. CONCLUSIONS

From the preliminary investigations on WEDC of 6061 aluminum alloy based MMC reinforced with three different percentage of the SiC particles it can be conclude that to achieve higher value of the average cutting speed, lower value of voltage and higher value of pulse-on time should be used. At any given value of any of the two input parameters the MMC with 7.5% SiC_p gives the highest value of the average cutting speed among the % of the SiC particles considered in this work. Through analysis of SEM, it has been observed that the depth of micro-voids and micro-cracks increases as the voltage and pulse-on time increase. In future the study can be extended using different work material, process parameters and performance measures.

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