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Technical Paper

Parametric optimization of wire electrical discharge machining on aluminium based composites through grey relational analysis

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ABSTRACT

Wire Electrical Discharge Machining (WEDM) is an advanced machining process, which is suitable for making complex shapes in conducting materials including metal matrix composites (MMCs). In the present work, an analysis has been made to optimize the process parameters such as peak current, pulse on time, wire feed rate and wt.% of Boron Carbide (B_4C) that affect the output responses, namely, kerf width (*K*) and surface roughness (SR), through the Grey Relational Analysis (GRA). Aluminium (6351) alloy reinforced with 5 wt.% Silicon Carbide (SiC) and 0, 5, 10 wt.% of B_4C prepared through the stir casting process was used for the evaluation. The experimental results show that the optimal combination of process parameters were peak current of 12 A, pulse on time of 100 μs, wire feed rate of 6 m/min and B_4C content of 5 wt.%. The influence of the pulse on time is found to be more in affecting the combined objective with a contribution of 96.19%. The crater formation on the machined surface of the composite at optimum condition was also examined through the Scanning Electron Microscope (SEM).

1. Introduction

In order to meet the modern industry needs, such as high hardness, less weight, low density and high strength, research work in the field of materials and their developments has moved towards composite materials. in the past few years. Aluminium based composites with high strength, low density, good damping properties and high thermal conductivities, are suitable for many engineering applications, like vehicle drive shafts, automotive pistons, bicycle frames, cylinder block liners, etc. [1,2]. A few fabrication techniques are available to fabricate the particle reinforced metal matrix composite, among which the conventional stir casting process is a suitable one, since, it's relatively simple, inexpensive and also applicable for an industry where mass production is required [3]. The aluminium based composite prepared through the stir casting process has a better mechanical property since, it gives better bond between the matrix and the reinforcements, which makes it suitable for several applications.

The conventional machining techniques are not very effective to machine the composite material, due to the presence of hard reinforcement particles alternatively which leads to increased tool wear. Hence, a non-traditional machining technique is required. Among the available non-traditional processes, the WEDM is an accepted method to manufacture complex profiles in the composite material [4]. The selection of a proper cutting parameter is an important task in the WEDM, because, improper selection leads to wire breakage and short circuiting, and thus reduces the production rate [5,6]. Since, the kerf width and surface finish are the major output responses in the WEDM, many researchers have investigated them [7].

Obtaining the minimum kerf width is a major problem in the present industrial scenario. Kerf width is to be minimized in order to produce the various profiles with good accuracy. Hence, it is necessary to choose the optimum cutting parameters of the Wire-EDM without affecting the output response. Lal et al. have conducted experiments in the Al7075/Al_2O_3/SiC hybrid composite through Wire-EDM to determine the effect of the process parameters, and found that the pulse on time is the major contributing factor [8]. Yan et al. have done the experimental work in the machining of Al 6061 alloy with varying percentage of Al_2O_3 and the results show that the increase in the reinforcement percentage increases the kerf width [9]. Huang and Liao have done WEDM study on the alloy steel with varying parameters, such as table feed rate, pulse-on time, pulse-off time, wire velocity, wire tension and fluid pressure and concluded

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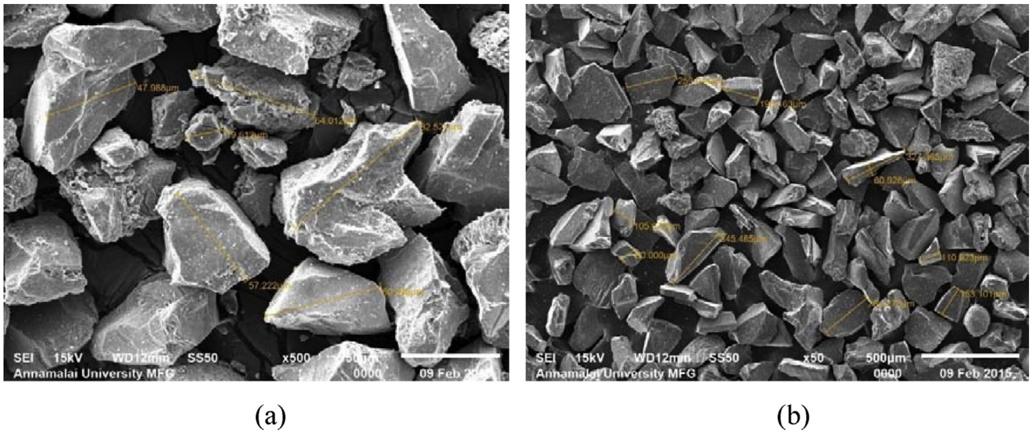

Fig. 1. Initial morphology (a) SiC (b) B_4C.

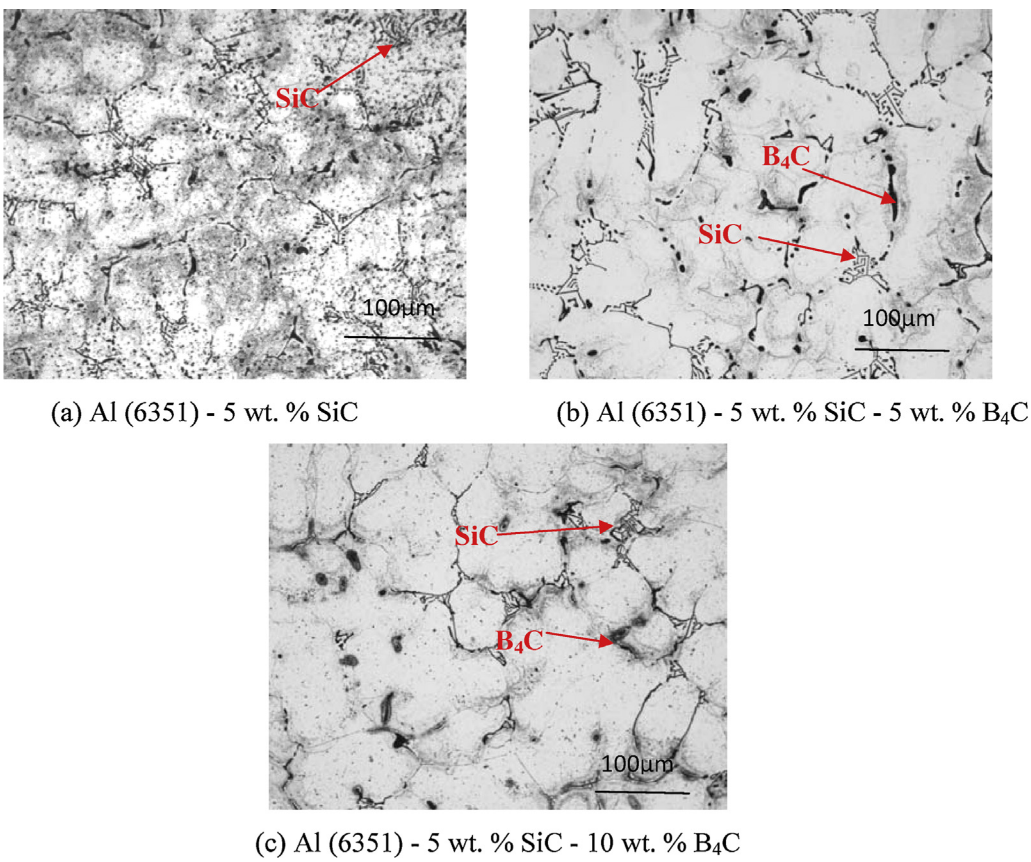

Fig. 2. Microstructure of the composites.

Table 1
Properties of the composite specimen.

Composites	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Density (kg/m^3)	Hardness (HB)
Al–5 wt.% SiC	81.37	105.62	2725	66.81
Al–5 wt.% SiC–5 wt.% B_4C	98.75	120.32	2715	71.58
Al–5 wt.% SiC–10 wt.% B_4C	107.43	132.48	2705	76.78

that pulse-on time has a major influence on the surface roughness and gap width [10]. Dongre et al. have studied the effect of WEDM parameters on the slicing of silicon ingots and have concluded that the kerf width is more influenced by the pulse on time and voltage [11].

The quality of the machined surface is also determined by the surface finish of the composites. Patil and Brahmankar have investigated the effect of the machining parameters on surface finish and cutting speed, and developed a mathematical model in order to relate the performance characteristics to the cutting parameters