

Chapter 15

Optimization of Drilling Process on Al–SiC Composite Using Grey Relation Analysis

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ABSTRACT

This study reveals the multi objective optimization of machining parameters in drilling of SiC reinforced with aluminium metal matrix composites through grey relational analysis. The composite is prepared with varying volume fraction of the reinforcement by liquid metal stir casting technique. Uniform distribution of SiC particle in the matrix is witnessed through microscopy study and observed that the hardness and strength on different composite. The drilling experiments were performed with coated carbide tool with different point angle such as 90°, 120° and 140°. Cutting speed, feed, point angle and volume fraction are considered as input parameters and the performance characteristics such as surface roughness and thrust force are observed as output response in this study. The significant contributions of these factors are determined using Analysis of Variance (ANOVA). The optimized process parameters have been validated by the confirmation test. The experimental result shows that point angle influences more on output performance followed by feed and cutting speed.

1. INTRODUCTION

Metal Matrix Composite (MMC) comprises a metallic matrix with one or more reinforcement materials to produce composite materials with superior properties like high temperature resistance, high wear resistance, corrosion resistance and good damping characteristics. These MMCs are primarily used in the aerospace, military and automobile industries. Cast metal matrix composites with particulates,

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whiskers and short fibers fabricated through stir casting technique (Thirumalai Kumaran et al., 2015; Suresh Kumar et al., 2014). Aluminum is the most frequently used matrix material due to its low density and ease of fabricability. SiC ceramic particles are often used as reinforcement within the Al matrix, because of its extreme hardness and temperature resistant properties. However, the higher hardness of these materials is one of the challenging factors for machining the engineering components to its final shape (Frank Muller & John Monaghan, 2000). In order to improve the machining efficiency and to reduce the machining cost it is important to select the optimal machining conditions (Coelho, 1995).

The surface finish determines the quality of the machined part. It is influenced mainly by the process parameters such as tool geometry and cutting conditions [cutting speed, feed rate and depth of cut. For achieving better surface finish one has to sacrifice the material removal rate. The increase in material removal rate decreases the production time of the component. Selection of suitable machining parameters is required for obtaining higher material removal rate without affecting the surface texture and quality of the finished product (Thirumalai Kumaran and Uthayakumar, 2014).

Gul Tosun and Mehtab Muratoglu (2004) observed that the carbide drills provide a better surface finish compared to the tools such as HSS and TiN coated HSS drills during drilling Al/17% SiCp MMC. Basavarajappa et al. (2007) suggested that better surface finish is obtained in TiN coated carbide drill than carbide tools during drilling Al-SiC MMC. This is due to hard coating present over the surface of the tool, which facilitates reduced build-up-edge formation during drilling. The increase in feed rate has a more predominant effect on surface roughness than cutting speed rate. Paulo Davim et al. (2001) and Ramalu et al. (2002) found that the predominant effect of feed rate is due to the burnishing or honing effect produced by the rubbing of small SiC particles trapped between the flank face of the tool and the work piece surface. Gul Tosun and Mehtab Muratoglu (2004) revealed that as the point angle of drills increases, the subsurface damage zone also increases leading to lower surface finish. The thrust forces during drilling increases considerably when higher feed rates and there is no predominant variation when the spindle speed is increased (Barnes, 1999). Edith Morin, et al. (1995) observed that the values of torque and thrust forces for 6061 Al alloy are very similar to that of composite and identified that the matrix is the one which controls drilling forces and not the reinforcing particles.

Taguchi method has been used for the optimization of single response problems for most of the applications. But for the evaluation of multi response problems the grey relational analysis based on grey system theory can be used effectively (Lin, 2002). Nihat Tosun (2006) used the grey relational analysis to determine optimal drilling parameters with the objective of minimization of surface roughness and burr height. Noorul Haq et al. (2008) optimized the drilling parameters with the consideration of multi responses such as surface roughness, cutting force and torque. Thirumalai Kumaran et al. (2015) used the Grey relational analysis to optimize the input process parameters of abrasive water jet machining. They reported that the selected methodology was useful to determine the suitable machining characteristics.

The objective of the present paper is to fabricate the A356-SiC composites by liquid metal stir casting technique. The optimal machining characteristics are determined by Grey relational analysis. Further the contribution of parameters such as speed, feed rate, point angle and volume fraction of reinforcement during drilling are determined using ANOVA finally the optimal parameters obtained from Grey relational analysis are validated experimentally.

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