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Influence of Milling Process Parameters on Machined Surface Quality of Carbon Fibre Reinforced Polymer (CFRP) Composites Using Taguchi Analysis and Grey Relational Analysis

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Abstract: The article presents the milled surface quality of Uni-Directional Carbon Fibre Reinforced Polymer (UD-CFRP) composites from Taguchi's and grey relational analysis. The novelty is demonstrating the possibility of detecting the surface defects in polymer composites during milling using SEM analysis. The material used for this study is UD-CFRP composite laminates and made by hand-layup process. All the milling operations were carried out using a solid tungsten carbide end milling tool and experiments conducted on CNC milling machine. Taguchi L9, 3-level orthogonal array was considered for experimentation. Analysis of Variance (ANOVA) was conducted to explore the significance of each individual input process parameters on multiple performance characteristics. Optimal process parameters are thoroughly validated by grey relational grade achieved by the grey relational analysis for multi performance characteristics. Finally, experimental results were correlated and analyzed with scanning electron micrographs using Scanning Electron Microscope (SEM).

Keywords: UD-CFRP composites, Machined surface quality, Machining damage, SEM, Surface integrity.

1. Introduction

Carbon Fibre Reinforced Polymer (CFRP's) can be costly to produce but are widely used where a greater degree of strength and durability is needed, such as aerospace, good shipbuilding, automotive, civil engineering, sports equipment, and a growing number of consumers and technological applications. Machining of composite materials is a moderately complex mission owing to its heterogeneity and the number of problems elevated such as surface failures, and inters laminar defects. Due to material characteristics and based on selection of process parameters, these damages might be caused. The processing operations in the manufacturing sector have mainly been used in fibre-strengthened plastics, since components made of composite materials are frequently made by net form, which often requires the removal of excess material to control tolerances. Milling is a suitable process to produce high-quality surface areas well defined in secondary manufacturing products with a closed tolerance [1]. The machinability of fibre-reinforced polymers (FRPs) depends heavily on the type of fibre integrated into a composite. Mechanical and thermal characteristics are extremely important for machining FRPs. Mechanics of cutting composites have a greater effect on the choice of cutting tools, machining parameters and other machinable conditions (cutting material and geometry).

Knowing that the right resources are gathered with the right material is important. The knowledge of cutting processes is important in the context of cutting mechanics and the machinability assessment in milling [1, 2]. Composites such as Carbon Fibre Polymers (CFP), made from carbon fibres to strengthen plastic resin patterns such as epoxy resin,

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