The International Journal of Advanced Manufacturing Technology (2018) 99:1351–1360
https://doi.org/10.1007/s00170-018-2544-2

ORIGINAL ARTICLE

Investigations on performance characteristics of GFRP composites in milling

I. S. N. V. R. Prasanth[1] · D. V. Ravishankar[2] · M. Manzoor Hussain[3] · Chandra Mouli Badiganti[4] · Vinod Kumar Sharma[5] · Sunil Pathak[6]

Received: 29 May 2018 / Accepted: 9 August 2018 / Published online: 21 August 2018

Abstract

Milling of *glass fiber reinforced polymer* (GFRP) composites becomes essential in order to enhance its surface quality by improving its dimensional tolerances, and minimizing the surface defects. In present work, investigations were done to optimize the four important milling parameters, namely, spindle speed (N), feed rate (f), depth of cut (t), and type of milling tool on performance characteristics (i.e., machining force (F_m) and surface roughness (R_a)). Taguchi L25 orthogonal array was used for experimental planning, and analysis of variance (ANOVA) has been used to identify the contribution of each considered parameters on performance characteristics of unidirectional (UD) GFRP composites. Optimum combination of parameters, i.e., spindle speed 1950 rpm, feed rate 1 mm/s, depth of cut 1 mm, and type of milling tool as two-fluted brazed carbide tipped end mill tool, were identified to achieve minimum values of machining force and surface roughness. Scanning electron microscope (SEM) was used to study the surface morphology of UD-GFRP composite laminates. Minimized subsurface damages were found, when milled with customized two-fluted brazed carbide tipped end mill tool.

Keywords Milling · UD-GFRP · Composites · Machining force · Surface roughness · ANOVA, SEM

1 Introduction

In recent years, glass fiber reinforced polymer (GFRP) composites have been extensively used in various production industries, automobile sectors, and marine applications. Though the products are made of GFRP composites that primarily gain their shape in the curing cycle, machining is necessary for closed dimensional accuracy in final product assembly [1–5]. Surface roughness has been considered as one of the most important surface quality measures that affect the dimensional accuracy of machined slots, holes, key ways, and special circumstances where composites were mating with other parts. GFRP composites are generally inhomogeneous in nature, possess anisotropic properties, and have abrasive behavior. Therefore, proper selection of cutting process parameters and selection of the cutting tool plays a key role during machining [4]. Milling of GFRP composites is majorly influenced by the catastrophic nature of material characteristics. During the machining, composites may fail due to the use of unoptimized machining forces. Also, while improving the surface quality of composites, some damages such as delamination and resin/fiber peel-up may occur. In order to overcome these problems, and obtain the preferred machined surface quality, it is essential to understand the machining mechanisms and use of optimized values of process parameters [5–9].

Various researchers have studied the effects of process parameters on machining of composite materials. Machinability characteristics of GFRP have been studied in drilling [6] and end milling [7]. They highlighted that machinability characteristics can be improved by preferred tool materials, tool

✉ Sunil Pathak
sunilpathak87@gmail.com; sunilpathak@ump.edu.my

[1] Department of Mechanical Engineering, Guru Nanak Institute of Technology, Hyderabad, India

[2] Department of Mechanical Engineering, TKR College of Engineering, Hyderabad, India

[3] Department of Mechanical Engineering, JNTUH, Hyderabad, India

[4] Department of Mechanical Engineering, RISE Krishna Sai Prakasam Group of Institutions, Ongole, India

[5] Department of Thermal and Energy Engineering, School of Mechanical Engineering, Vellore Institute of Technology, Vellore 632014, India

[6] Faculty of Engineering Technology, University Malaysia Pahang, Kuantan, LebuhrayaTunRazak, 26300 Gambang, Kuantan, Malaysia