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Sustainable machining of CFRP: Evaluation of tool wear and surface quality under variable cutting conditions

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Source JURNAL TRIBOLOGI

View Journal Impact

Volume: 50 Page: 152-165

Published SEP 2026

Indexed 2026-10-22

Document Type Article

Abstract CFRP is extensively utilized in aerospace and automotive industries for its exceptional strength-to-weight ratio, which contributes significantly to structural weight reduction and improved fuel efficiency. However, its anisotropic and heterogeneous structure imposes significant challenges during machining. The abrasive nature of carbon fibers accelerates tool wear, especially at high cutting speeds, resulting in tool degradation such as edge rounding and flank wear. Moreover, machining above the polymer matrix's glass transition temperature (Tg) worsens surface defects such as matrix smearing and fiber pull-out due to thermal softening. This study systematically investigates the influence of cutting speeds, Vc(130 and 170 m/min) and cutting conditions (dry and chilled air) on tool wear progression and surface roughness during milling of CFRP using uncoated tungsten carbide tools. The highest tool wear (110 mu m) was recorded during milling with Vc=170 m/min under chilled air condition, which is 25.5% higher than dry condition in similar cutting speed. This is primarily attributed to thermal fatigue induced by cyclic heating and cooling at the tool-workpiece interface. Conversely, dry machining produced the highest areal surface roughness (Sa = 5.015 mu m), which is 27% higher than chilled air, due to excessive frictional heat. These findings underscore the critical role of optimized cutting parameters and cooling strategies in mitigating tool wear and enhancing surface quality during CFRP machining.

Keywords **Author Keywords:** Tool wear; Abrasion; Surface roughness; CFRP
Keywords Plus: DRY

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