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Influence Of Procedure-Related Cutting Edge Micro Geometry Modification On The Production Quality When Milling Fibre Reinforced Plastics

Eckart Uhlmann[a], Bartek Stawiszynski[a], Falk Protz[a,*], Lukas Prasol[a]

[a]*Institute for Machine Tools and Factory Management (IWF), Technical University Berlin, Pascalstr. 8-9, 10587 Berlin, Germany*

Abstract

The importance of carbon or glass fibre reinforced plastics in aviation and automotive industry has increased considerably over the last twenty years. The latest generation of commercial aircrafts for example exhibits a composite weight proportion of up to 50 %. To generate the final contour and to realize appropriate interfaces for following assembly processes, modern tools and manufacturing technologies are required to ensure high workpiece qualities. The combination of strength enhancing fibres, a ductile matrix and various laminate structures highly strains the cutting edge during the cutting process. For this field of application various cutting edge and tool geometries has been developed by several tool manufacturers to maximize wear resistant and shape accuracy. The wear mechanism and course of different cutting materials and its influence on workpiece quality during trimming of carbon and glass fibre reinforced plastics were analysed. It could be shown that an increasing tool wear does not cause necessarily low workpiece qualities. Additionally, the influence of different process parameters and strategies on the cutting edge micro geometry forming and the workpiece quality were analysed.

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Keywords: Fiber reinforced plastics; milling; diamond coating

* Corresponding author. Tel.: +49-30-314-23293; fax: +49-30-314-25895.
E-mail address: protz@iwf.tu-berlin.de

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1. Introduction

Innovative lightweight design for aeronautical and automotive applications requires the use of modern materials, such as fibre reinforced plastics (FRP). In urban transport industry, usually glass or carbon fibre reinforced plastics (GFRP/CFRP) are selected as composite material for structural components [1]. The demand for economical machining strategies for FRPs is therefore high and represents the latest challenge in the tool and process development, as well as in industrial application [2-7]. In recent years, the use of modern production strategies, such as bore-milling, ultrasonic assisted milling (UAM) and high speed cutting (HSC) as an economic and productive approach for machining FRPs was investigated. It was shown that especially HSC and UAM show the highest potential to minimize damages on the surface and subsurface of FRP due to a change in the fibre failure mechanism [5-17]. Furthermore, the application of alternative cutting materials for the machining of FRPs, e.g. ceramics, is investigated systematically. Due to disadvantageous wear mechanisms on carbide tools, silicon aluminum oxide nitride ceramics (SiAlON) and other silicon based nitrides or carbides were tested and show suitable results in cutting experiments [19-21]. Overall, few of these research works demonstrated the effects on the process regarding a change of the cutting tool geometry and the resulting workpiece qualities. The aim of the presented work is to show the influence of procedure-related cutting edge micro geometry forming on the workpiece quality when using different process strategies and cutting tool materials.

Nomenclature

a_e	width of cut
a_p	depth of cut
b_{iSTSW}	distance between the highest points of the STSW
b_s	width of edge
CAE	carbide end mills
CEE	ceramic end mills
CFRP	carbon fibre reinforced plastics
CIS	cutting edge radius initial state
d	fibre diameter
d_{ae}	aerodynamic diameter
d_{WC}	average grain size
D_a	damage amount
D_d	damage depth
D_{def}	amount of the determined deformation
f	swing frequency
F_f	feed force
F_{fN}	feed perpendicular force
F_p	passive force
FRP	fibre reinforced plastics
GFRP	glass fibre reinforced plastics
h	loss of height
h_s	height of edge
HSC	high speed cutting
HV	vickers hardness
l	work piece length
l_F	milling path
n	rotational speed
p_c	clamping pressure
PM1	mass fraction concentration- $d_{ae} \leq 1$ µm
PM2.5	mass fraction concentration- $d_{ae} \leq 2.5$ µm
PM4	mass fraction concentration- $d_{ae} \leq 4$ µm