Wear Behaviour of Tungsten Carbide in End Milling Process of Aluminium Alloy 6061-T6 with Minimal Quantity of Tri-hybrid Nanofluids

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ABSTRACT

Nowadays, using nanotechnology in science and industry improves the yield of different processes. The machining process using hybrid nanofluids requires further research to better understand the mechanism of tool wear and the fundamental aspects are not yet ventured. In machining, tool wear is common problems that exist for quite some time. In addition, milling process of Aluminium Alloy was challenged due to a strong adhesion particularly in higher temperature. Deposition of chips material during the process at the tool edge may induce several tool failures such as build-up edge, chipping and flaking. Eventually, tool life, manufacturing cost and product quality were the factors that normally effects by tool wear. However, the severity of tool wear can be reduced by applying a cutting fluid to the tool-workpiece interface. This paper intends to discover the effects of tri-hybrid nanofluids in end milling process of Aluminium Alloy 6061-T6 mainly on wear conditions of uncoated and double-layered PVD coated inserts. In this research works, three different nanoparticles SiO_2-Al_2O_3–ZrO_2 were dispersed in 60:40 of deionized water and ethylene glycol. The concentration was prepared between 0.06 and 0.12 wt.%. The MQL system with assisted air pressure was employed to deliver newly developed tri-hybrid nanofluids. During metal cutting process, the metal working fluid was supplied intermittently based on flow rate setting in the MQL system to the cutting zone with a very minimal quantity. A single insert was used and changed for every 100 mm of cutting length at different machining parameters. The effects on wear mechanisms were closely examined at the flank area using scanning electron microscope. Through comprehensive investigation, the wear mechanisms consist of attrition, flaking, abrasion and coating delamination. Other phenomenon such as thermal crack was observed in the wear region. The tool failures have a relationship with machining parameters and cutting tool condition itself. It can be concluded that, coating delamination and abrasion quite severe for coated inserts. While, uncoated tools were severe with attrition mode of failures. At extreme machining condition, higher temperature and friction forces at the tool-workpiece interface have a significant effect on the tool failures. For further investigation, the effects of tri-hybrid nanofluids on wear behaviour of tungsten carbide inserts can be examined for other machining process with different workpiece material.

KEYWORDS
End milling process; Tri-hybrid nanofluids; Flank wear; Attrition; Abrasion; Flaking; Delamination; Thermal crack

ACKNOWLEDGMENT
The authors are grateful for the support given by Universiti Malaysia Pahang for providing research grants PDU213204.