Efects of SiO2-Al2O3-ZrO2 Tri-hybrid Nanofuids on Surface Roughness and Cutting Temperature in End Milling Process of Aluminum Alloy 6061-T6 Using Uncoated and Coated Cutting Inserts with Minimal Quantity Lubricant Method

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ABSTRACT

In machining, heat concentration is generated at the surface contact between the tool and workpiece. This is the effect of hard frictions at the shear cutting plane to remove hard and brittle materials. The highly adhesive behavior of aluminum alloy 6061-T6 is more severe in higher cutting temperature, which may affect tool failures such as flank wear, tool chip and built-up edge, particularly on the edge of cutting inserts during the process. As a result, this may lead to the rough surface and low-dimensional accuracy of the machined parts. Realizing that metal-cutting industry players are demanding high-quality products with better surface finish and dimensional accuracy led to this study. Aluminum alloy 6061-T6 is a standard alloy used in automotive, aerospace and food packaging due to good hardness, high strength-to-weight ratio, resistance to corrosion and weldability. In order to address this problem, a newly developed metal working fluid which is SiO2-Al2O3-ZrO2 tri-hybrid nanofluid is applied in the cutting zone to achieve a good surface finish of the machined parts and lowering the cutting temperature. This study is the first attempt to enhance machining performance, particularly at high-speed machining, by employing a combination of tri-hybrid nanofluids and a minimum quantity lubricant technique. Industrial standards include uncoated tungsten carbide and CVD TiCN-Al2O3 carbide used during machining of aluminum alloy 6061-T6. The minimum quantity lubricant method is an alternative in supplying the lubricant into the machining zone due to flood machining and conventional fluid possess safety, health, economic and environmental effects. In this study, the experimental data were analyzed statistically using analysis of variance and response surface methodology. The responses studied were reduced significantly when tri-hybrid nanoparticles present at the cutting interface with higher MQL flow rate and concentration. There are two-factor interactions which are significant to the responses studied. Therefore, the combinations of MQL and excellent tri-hybrid nanofluids characteristics have enhanced between 16 and 76% of surface roughness and the cutting temperature, respectively, which is very promising in the future.

KEYWORDS: MQL, Tri-hybrid nanofuid, Machining, Surface roughness, Cutting temperature, Aluminum alloy 6061-T6

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