Thermal analysis of SUS 304 stainless steel using ethylene glycol/nanocellulose-based nanofluid coolant

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Abstract

Green cooling system usage in machining is getting favors to minimize the environmental effect such as pollutions. Around 20% of the machining cost is about coolant usage in flooded cooling technique. Even though coolant has a reasonably low cost, their handling and disposing cost are very high and also, threatening toxic contents, disposal of used coolant is a big problem as it can lead to hazardous effect to the machining operates as well as to the environment. As an alternative, a cooling technique known as minimum quantity lubrication (MQL) was introduced in the machining operation. For MQL technique, the coolant should exhibit superior properties which are effective in machining operation when compared with the conventional machining coolant which is metal working fluid (MWF). Owing to the technology advancements by nanotechnology in nanomaterial, the nanofluid is a promising coolant that can replace the conventional machining coolant. In the present work, ethylene glycol/nanocellulose-based nanofluid is evaluated in terms of its thermo-physical properties and its effectiveness in machining performances which is temperature distribution in cutting tool and compare its effectiveness with MWF. Its effectiveness is tested in turning machining operation of SUS 304 stainless steel using cemented tungsten-cobalt (WC-Co)-coated carbide cutting insert. The turning operation by using ethylene glycol/nanocellulose-based nanofluid coolant with 0.5 vol% which exhibit a superior thermal conductivity of 0.449 W/m K than 0.267 W/m K thermal conductivity of MWF at 30 °C. The recorded lower amount of heat transfer to the cutting tool is 863 J compared with 1130 J when using MWF. On the other hand, the maximum temperature reading recorded at chip formed by using MWF is 225 °C whereas by using nanofluid is 154 °C which promises lower temperature distribution to chip formed during the machining operation. Also, the functionality of nanofluid as a thermal transport during machining is proven via chip formation observation analysis and scanning electron microscope (SEM) with energy-dispersive X-ray (EDX) spectrum analysis.

Keywords Nanocellulose · Thermal · Thermal conductivity · Machining