ABSTRACT

Cutting fluids play a prominent role in the metal working industries, to enhance the tool life and surface finish of the machined products. The deprived heat transfer and lubricating property of these conventional cutting fluids causes severe problems to meet the demands of the machining process. Earlier efforts by the suspension of micron-sized metallic particles towards the improvement of the thermo-physical properties of conventional fluids failed due to sedimentation, clogging, and erosion, etc. Nanotechnology arises as an alternate solution to enhance the functional properties of the materials due to its potential features. In recent years, nano-size solid particles have received considerable attention and widely used as additives to improve the thermal and lubricating properties of the cutting fluids.

In the current research work, nano-cutting fluids were formulated by dispersing silver, copper and aluminium oxide nanoparticles in the mineral oil based cutting fluid, in different volume fractions based on the literature review. Experiments were conducted to validate the enhancement in the thermo-physical properties such as density, pH value, thermal conductivity, viscosities and dispersion stability of the developed nano-cutting fluids and also compared with the results of conventional cutting fluid. To assess the tribological characteristics of the synthesized nano-cutting fluids anti-wear and extreme-pressure (EP) tests were performed in Four-ball tester as per ASTM D4172 and ASTM D2783 standards, respectively. The enhancement in the anti-corrosive properties of the nano-cutting fluids was investigated through the iron-chip corrosion test as per ASTM D4627 standard. To minimize the consumption of cutting fluids, portable minimum quantity lubrication (MQL) system was developed. The

process parameters associated with MQL system was optimized through Taguchi method and grey relational analysis in order to attain higher effectiveness.

The modified cutting fluids were used as a lubricant in the rough turning operation performed at optimized machining parameters, to examine the suitability and cutting performance. The cutting fluids were applied through flood lubrication and minimum quantity lubrication methods. The cutting temperature, cutting force, tool wear and surface roughness of the finished work piece were measured during the machining operation to evaluate the cutting performance.

The experimental results indicate the significant improvement in the thermo-physical properties with the inclusion of nanoparticles in the base cutting fluids. From the Zeta potential measurements, the copper nanoparticles found to have better stability in the dispersed medium. The cutting fluid containing silver nanoparticles and aluminium oxide nanoparticles with 2% and 1% volume fraction respectively, showed maximum reduction in the wear rate and coefficient of friction. The high load carrying capacity was observed for base fluid with the inclusion of 2% silver nanoparticles. All the nanoparticles in the base fluid at 1% and 2% volume fraction exhibit a better resistance towards corrosion. During the rough turning operation, it was perceived that the nano-cutting fluids through MQL system have greater influence in the reduction of cutting temperature, surface roughness and tool wear. The lowest cutting temperature and tool wear was acquired for silver based nano-cutting fluids through MQL system. Higher surface finish was attained for the 2% aluminium oxide based nano-cutting fluids. From the experimental results, it was observed that the silver based nano-cutting fluids exhibit superior performance than copper and aluminium oxide based cutting fluids.