Minimum Quantity Lubrication (MQL) Grinding Using Nanofluids

Research Assistants/Staff:
Bin Shen

Faculty:
Albert Shih

Objectives

- Through the application of high heat transfer performance fluids - nanofluids, a practical and environmental benign grinding process is to be developed.

State-of-the-Art

- Nanofluids are a new class of heat transfer fluids engineered by dispersing nanometer-size solid particles in traditional heat transfer fluids to increase thermal conductivity and heat transfer performance.
- From an environmental and economical point of view, there are critical needs to reduce the use of cutting fluid in grinding process. Minimum quantity lubrication (MQL) grinding is to supply a minute quantity of cooling lubricant medium to the grinding zone so that the applied amount of grinding fluid can be reduced tremendously. It is a promising solution, however, it has shortcoming of insufficient workpiece cooling capacity.

Approaches

- Formulation of new nanofluids.
- Characterization of nanofluids thermal conductivity and convection heat transfer coefficient.
- MQL grinding technology is developed to reduce the amount of grinding fluid. Advanced thermal and tribological properties of nanofluids may enable MQL grinding.

Accomplishments

1. Nanofluid Formulation

Materials	Average particle size (nm)
Aluminum oxide	10 nm, 20 nm, 30 nm, 40 nm, 80 nm, 160 nm
Aluminum nitride	20 nm
Diamond	100 nm, 200 nm
Carbon nanotubes	10-20 nm or 40-60 nm in diameter; 1-2 μm or 5-15 μm in length

- Most nanofluids can be formulated by two-step physical method.
- Special treatment is necessary in preparation of nanofluids containing multi-wall carbon nanotubes (CNTs). With surfactant along with ultrosonic bathing, multi-wall carbon nanotubes are being able to be dispersed in distilled water or ethylene glycol.

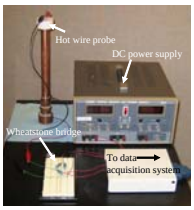
Al_2O_3 nanofluids

Diamond nanofluids

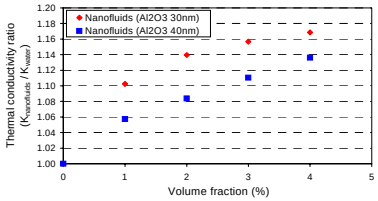
CNTs suspensions in water

2. Nanofluids Characterization

- Thermal conductivity measured by hot wire method.

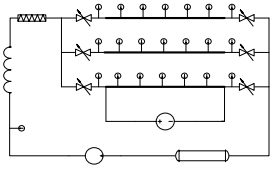


Thermal conductivity measurement apparatus

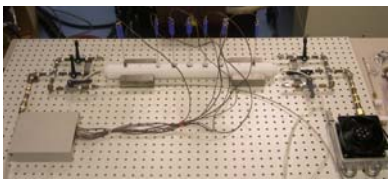


Thermal conductivity measurement of Al_2O_3 nanofluids

- Convection heat transfer coefficient measurement



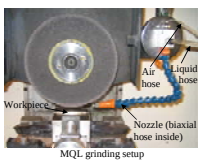
Convection heat transfer measurement schematic drawing



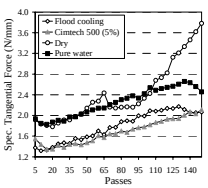
Convection heat transfer measurement apparatus

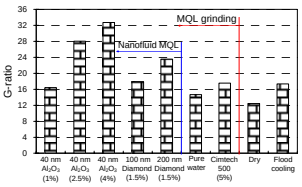
3. MQL Grinding Using Nanofluids

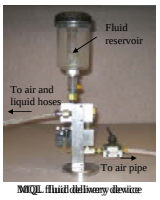
- Generally, the application of nanofluids can reduce grinding forces, improve the wheel wear (high G-ratio), and generate better surface finish.



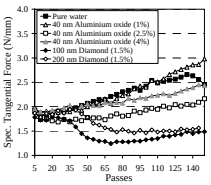
MQL grinding setup

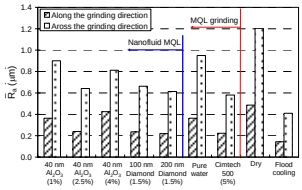






MQL fluid delivery device





Future Work

- Formulation of new nanofluids for practical MQL grinding application.
- Study of convection heat transfer performance of nanofluids.
- Grinding temperature measurement and thermal model development for MQL grinding using nanofluid.

Sponsors

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For more information, contact Prof. Albert Shih; Phone: 734-647-1766; Email: shiha@umich.edu