

Potential of Nanofluids as Cutting Fluids - An Evolution

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Abstract - Heat generation is the common phenomenon associated with machining zone. To protect the workpiece from thermal damage, coolant is required at the cutting zone. Cutting fluids commonly known as coolants limit the energy transferred to the work piece. In the past century various cutting fluids have been developed. Still there is a need to control the temperature of cutting zone. Nanofluids are the latest innovations to enhance the heat carrying capacity of lubricants. This paper reviews the latest developments in nanofluids. The review also highlighted the various challenges for the researchers.

Keywords: Nanofluids, thermal conductivity, coolants.

I. INTRODUCTION

Cutting fluids commonly used in machining zone for cooling, lubrication and chip evacuation. Cooling always remains major challenge for the manufacturing industry [1] [2]. Hard materials produced a lot of heat during machining, conventional methods of cooling stretched to their limits [3, 4]. Large quantity of cutting fluids were used for efficient cooling of machining zone. This cooling is referred as flood cooling. Lately questions were arises on the negative effects of excessive use of cutting fluids. They are harmful to workers as they hazardous gases at the cutting zone, also they damaged the soil when appropriately discharged into the ground [5]. There is a need to eliminate traditional cutting fluids and to develop new fluids [6]. Nanofluids is one of the new concept.

II. NANOFUIDS

Nanofluids, which are solid-liquid composite materials consisting of nanometer sized solid particles, fibers, rods or tubes suspended in different base fluids, provide a promising technical selection for enhancing heat transfer because of its many advantages besides anomalously high thermal conductivity [7]. Solid metals with high thermal conductivity can be used as nano-particles in base fluid to form nanofluids. Water, oil ethylene glycol are commonly used base fluids. Preparation of nano particles plays a key role in enhancing thermal conductivity. Two popular method of producing nano-particles are one step method and two step method. Eastman et al [8] produced the nanofluids by one-step physical method. Liu [9] produced waterbased nanofluid using Cu nanoparticles by chemical reduction method [9]. Hong [10] prepared Fe nanofluids by dispersing Fe nanocrystalline powder in ethylene glycol by

a two-step procedure. Thermal conductivity [11] of various metal commonly used for nanoparticles are shown in table 1.

TABLE 1 THERMAL CONDUCTIVITY OF VARIOUS NANOPARTICLES AND BASE FLUID

	Material	W/mK
Metallic Solids	Cu	401
	Al	237
	Ag	428
	Au	318
	Fe	835
Non-Metallic Solids	Al ₂ O ₃	40
	CuO	76.5
	Si	148
	SiC	270
	CNTs	3000
Base Fluids	H ₂ O	0.613
	Ethylene Glycol	0.253
	Engine Oil	0.145

III. THERMAL CONDUCTIVITY OF NANOFUIDS

Eastman et al. [8], found that effective thermal conductivity of ethylene glycol is shown to be increased by up to 40% for a nanofluid consisting of ethylene glycol containing approximately 0.3 vol% Cu nanoparticles of mean diameter, 10 nm. Liu et al. [9] show that Cu-water nanofluids with low concentration of nanoparticles have noticeably higher thermal conductivities than the water base fluid without Cu. For Cu nanoparticles at a volume fraction of 0.001 (0.1 vol.%), thermal conductivity was enhanced by up to 23.8%. Hwang et al. [12] measured thermal conductivity enhancement of water-based MWCNT nanofluid up to 11.3% at a volume fraction of 0.01. The measured thermal conductivities of MWCNT nanofluids were higher than those calculated with Hamilton-Crosser model due to neglecting solid-liquid interaction at the interface. The results shows that the thermal conductivity enhancement of nanofluids depends on the thermal conductivities of both particles and the base fluid. In comparison with other nano structured materials dispersed in fluids, the nanotubes provide the highest thermal conductivity enhancement, opening the door to a wide range of nanotube applications. Thermal conductivity enhancement of poly oil with the addition of multiwalled carbon nanotubes (MWCNT) at 1% volume fraction was increased by 150% as reported by Choi et al. [13]. Kang et al. [14] measured the thermal conductivity of ethylene

glycol with 1.2% (v/v) diamond nanoparticles between 30 and 50nm in diameter . Remarkable results were obtained showing 75% enhancement. Lee et al.[15] revealed thermal conductivity of nanofluids is affected by pH level and addition of surfactant during nanofluids preparation stage. Yu et al. [16] conclude thermal conductivity of ethylene glycol based ZnO nanofluids measured by transient short hot wire technique is found to be increased non-linearly with nanoparticles volume fraction. Shen [17] also concluded that enhancement of thermal conductivity of metallic and non-metallic nanofluids.

IV.CONCLUSIONS

It has been found that enhanced thermal conductivities of nanofluids have attracted attention of researchers for many potential applications. As heat transfer has been enhanced so many devices can be made more efficient. Nanofluids has the potential to be used as coolant at the machining zone. There are challenges for the researchers regarding stability and production cost of nanofluids.

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