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Effect of Nanofluid on Heat Pipe Thermal Performance

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Abstract: - Nanofluid is employed as working medium for conventional 200 μm wide grooved circular heat pipe. The nanofluid used in the present study is an aqueous solution of various-solution sliver (Ag) nanoparticles. The average diameters of Ag nanoparticles is 10 nm. The experiment was performed to measure and compare thermal resistance of pure water and nanofluid filled heat pipes. At the same charge volume of 0.45mL, test result showed the average decrease of 30%-70% in thermal resistance of heat pipe with nanofluid as compared with pure water.

Key-Words: - Nanofluid, heat pipe, thermal resistance, nanoparticles.

1 Introduction

Over the past decade, the use of heat pipes in electronic cooling applications has increased dramatically, primarily in notebook computers. In fact, virtually every notebook computer manufactured today uses at least one heat pipe assembly. Typically used to carry less than 25 W of power, these parts are low in cost and highly reliable. Use of heat pipes in high-power (>150 W) cooling applications has been limited to custom applications requiring either low thermal resistance or having a severely restricted enclosure area. The cost of these larger diameter heat pipes was high due to a limited number of manufacturers and handmade assembly times.

With progresses of nanotechnology and thermal engineering, many efforts have been devoted to heat transfer enhancement. The usual enhancement techniques for heat transfer can hardly meet the challenge of ever increasing demand of heat removal in process of high energy devices. However, traditional fluids have poor heat transfer properties compared to most solid. Therefore, Argonne National Laboratory has developed the concept of a new class of heat transfer fluids called "Nanofluids," which are engineered by suspending ultrafine metallic or nonmetallic particles of nanometer dimensions in traditional fluids such as water, engine oil, ethylene glycol (Choi, 1995). Some experimental investigations have revealed that the nanofluids have remarkably higher thermal conductivities and greater heat transfer characteristic than those of conventional pure fluids [1-3]. A theoretical model and an experimental are proposed to describe heat transfer performance of nanofluid flowing in a tube, the experimental results illustrate that the thermal conductivity of nanofluids remarkably increases with the volume fraction of ultra-fine particles [4].

In 2001, nanofluid consisting of copper nanoparticles dispersed in ethylene glycol has a much higher effective thermal conductivity than either pure ethylene glycol or ethylene glycol containing the same volume fraction of dispersed oxide nanoparticles [5]. The convective heat transfer feature and flow performance of Cu-water nanofluids in a tube have experimentally been investigated by Xuan and Li [6]. Sarit et al. go detailed into investigating the increase of thermal conductivity with temperature for nanofluid with water as base fluid and particles of Al_2O_3 or CuO as suspension material, and the results indicated an increase of enhancement characteristics with temperature, which makes the nanofluids even more attractive for applications with high energy density than usual room temperature measurements reported earlier [7]. You and co-works performed boiling experiments, varying conditions of fluids. The measured pool boiling curves of nanofluids saturated at 60℃ have demonstrated that the critical heat flux increases dramatically (~200% increase) compared to pure water case [8].

In 2004, some researchers investigated gold nanofluid on meshed heat pipe thermal performance. The measured results show that the thermal resistance of the heat pipes with nanofluids is lower than with pure water [9].

2 Experimental Procedure

The nanoparticle used is silver particles of 10 nm in sizes. The base working fluid used is PURE-water. The test nanofluid was obtained by dispersing the nanoparticles (NANOHUBS TECHNOLOGY CO., LTD.) in pure water. The nanofluid concentration of 5 mg/l, 10 mg/l, and 15 mg/l (ppm) were used in the study. Figure.1 showed a TEM image of Ag nanoparticles with an average of 10 nm.

In the experiment, the outer diameter and length of the heat pipe are 6 mm and 180 cm, respectively. The heat pipe contained 200 μm wide grooves. An experimental system was set up to measure the thermal resistance of circular heat pipes (Figure.2). The local temperature on the heat pipe was measured by five isolated type-T thermocouples. Two thermocouples were attached to the evaporator; one was attached to the adiabatic section, the others were attached to the condenser section. All thermocouples were calibrated against a quartz thermometer. The uncertainty in temperature measurements was ± 0.1 □.

Two heater bars (maximum 180 W) were used as a heat source in the heating section. Thus, the heating load (Q) and temperature difference (dT) were measured, and the thermal resistance (R) was calculated by the equation, $R = dT / Q$.

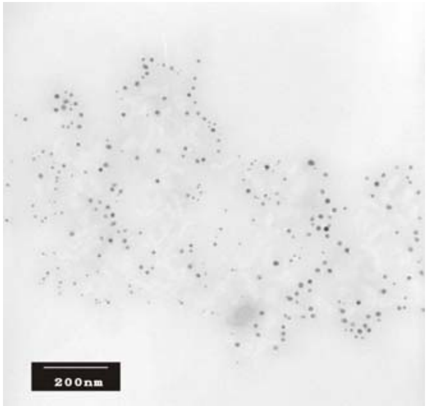

Fig.1 TEM micrograph of Ag nanoparticles

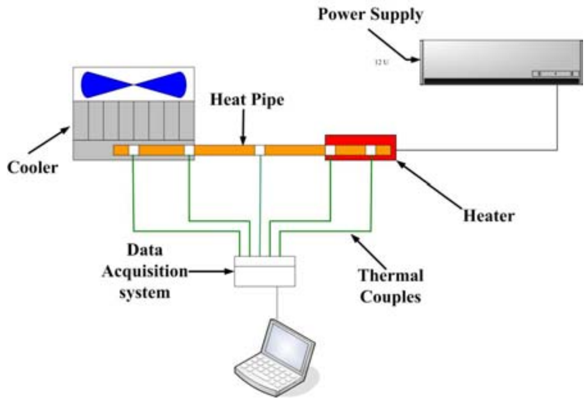

Fig.2 A schematic view of the system for measuring the thermal Performance of heat pipe with nanofluid

3 Results and Conclusion

Table1 presents the list of measured values of thermal resistance in different solutions and heat load. Fig.3 illustrates the effect of nanofluid concentration on the thermal performance of the grooved heat pipe. The thermal resistance of heat pipe containing pure water. The figure shows that the thermal resistance of the heat pipes with nanofluid solution is lower than that with pure water. . As a result, the higher thermal performances of the nanofluid have proved its potential as substitute for conventional pure water in the grooved heat pipe.

The major reason for reducing the thermal resistance of heat pipe by using nanofluid can be explained as follows. The convective heat coefficient of nanofluid is higher than pure water [10]. Therefore, it is expected that the thermal performance of heat pipe will be enhanced.

Table 1
Measured values of thermal resistance in different solutions and heat load.

Work fluid / R (℃/W) / Q(W)	Pure water	Ag nanofluid 5 ppm	Ag nanofluid 10 ppm	Ag nanofluid 15 ppm
60	0.040	0.023	0.027	0.025
80	0.055	0.018	0.018	0.019
100	0.067	0.016	0.017	0.017

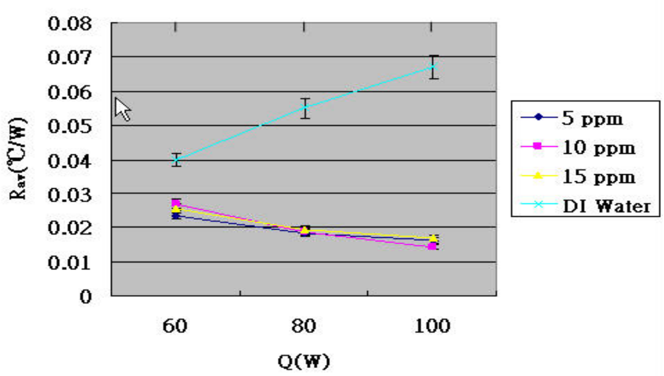

Fig.3 Measured values of thermal resistance of heat pipe with pure water and nanofluid prepared by different concentration.

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