ENHANCEMENT IN PERFORMANCE OF HEAT PIPE BY USING NANOFLUID

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Abstract— In this paper study the heat transfer performance of a various shape heat pipe using aqueous nanofluids as the working fluids. The base liquid was distilled water, while, the different kinds of nanoparticles: Cu with two mean diameters of 40 nm and 20 nm, CuO with two mean diameters of 50 nm and 20 nm and SiO with a mean diameter of 30 nm were added respectively into the base liquid to compose different kinds of nanofluids. Experiments were performed under three steady operating pressures of 7.45 kPa, 12.38 kPa and 19.97 kPa, respectively. Effects of nanoparticle kind, nanoparticle size, nanoparticle mass concentration and operating pressure on the evaporation and condensation heat transfer coefficients, the maximum heat flux and the total heat resistance of the heat pipe were investigated, compared and discussed. Experimental results show that adding Cu and CuO nanoparticles into the base liquid can apparently improve the thermal performance of the heat pipe and there is an optimal nanoparticle mass concentration to achieve the maximum heat transfer enhancement. However, adding SiO nanoparticles into the base ;fluid will contrarily deteriorate the heat transfer performance. The main reason that causes these differences its the heat transfer performance results from the surface structure of the coating layer formed by sediment of nanoparticle on the heated surface.

Keywords: Nanofluids, Nanoparticles, Heat pipe, Enhanced heat transfer

I. INTRODUCTION

With the increase of work frequency and heat flux of electronic components,the dissipation problem of the high heat flux component becomes one of the key technologies of the electronic device design .Up to now, heat pipe technology has been widely applied in the field of microelectronics cooling, as the improved construction of the general heat pipes, flat micro heat pipe has now become a hotspot technology of heat pipe research and development and has been widely applied in many fields, such as spacecraft thermal control, high heat flux electronic equipment cooling, medical and health undertakings, and household appliances. .

Heat pipe is a device used to transfer the heat from one place to the other. The heat pipe consists of evaporator section, adiabatic section and condenser section (Fig. 1.1). Heat absorption takes place in the evaporator section and heat rejection at the condenser section. Adiabatic section is fully insulated. The heat pipe is evacuated using a vacuum pump and is filled up with the working fluid. The working fluid absorbs the heat at one end of the heat pipe called evaporator and releases the heat at the other end called condenser. Due to the capillary action, the condensed working fluid through the screen mesh wick structure returns to the evaporator, on the inside wall of the pipe. Normally conventional fluids are used in heat pipes to remove the heat. For the time being, nanofluids play an important role in heat pipes to increase the heat transfer compared to conventional fluids.

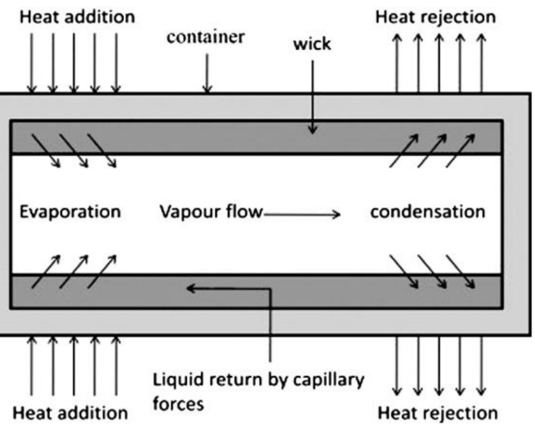

Fig. 1.1 Schematic diagram of heat pipe.

Thermal conductivity is an important parameter in enhancing the heat transfer performance of a heat transfer fluid. Researchers have also tried to increase the thermal conductivity of base fluids by suspending nanometer-sized solid particles in fluids since the thermal conductivity of solid is typically higher than that of liquids, as seen from Table 1.1 Many researchers have presented the heat transfer characteristics of heat pipe using nanofluids. The concept of “nanofluid” has firstly proposed by Choi and Eastma. That is, adding nanoscale metal or metal oxide particles in the liquid with a certain way and proportion,which forms a new class of heat transfer and cooling working fluid. Because of its stability and high thermal conductivity, the nanofluid shows a promising prospect in the heat transfer enhancement. The application of nanofluid research in heat pipes was firstly published by Chien et al. Over various articles have been published since then, involving mesh wicked heat pipes , micro-grooved heat pipes ,cylindrical miniature grooved heat pipes and so on. An experiment concerning a cylindrical screen mesh wicked heat pipe was performed by Nandy putra et al.The working fluid was an aqueous suspension of various-sized nanoparticles. The inner diameter and the length of the tested copper tube were 7.44 mm and 200 mm, respectively. A 200mesh screen was distributed on the inner wall.

The experimental results showed that the total thermal resistance of the heat pipe reduced a lot due to the addition of nanoparticles under the same cooling condition. The experiment also found that the best way to use nanofluids in the heat pipe was using a well dispersed nanofluid. The mechanism of the heat transfer enhancement was explained as follows: a major thermal resistance of heat pipe was caused by the formation of vapor bubbles at the liquid–solid interface; the suspended nanoparticles tended to bombard the vapor bubbles during the bubble formation; therefore, it was expected that the nucleation size of vapour bubbles was much smaller for the fluid with suspended nanoparticles than that without them.

Table 1.1 Thermal conductivities of various solids and liquids.

Thermal conductivities (w/m-k)	Material
401	Metallic solid copper
237	Aluminium
148	Non-metallic solid silicon
40	Alumina (Al_2O_3)
72.3	Metallic liquid sodium
0.613	Non-metallic liquid water
0.253	Ethylene glycol (EG)
0.145	Engine oil (EO)

2.LITERATURE REVIEW

The powder form nanoparticles which disperse in base liquids are called nanofluids. Nanofluids can be produced by two techniques; the two-step (double-step) method, and one-step (single-step) method. These methods have been utilized using different types of chemical and physical techniques to make sure that the solid–liquid mixture is stable to avoid agglomeration, additional flow resistance, possible erosion an clogging, poor thermal conductivity, and poor heat transfer. The two step method is done by producing the nanoparticle powder initially as introduced in the previous section, and then disperses them into a host liquid.However, in one-step method the nanoparticles are simultaneously made and directly dispersed into the base fluid. It is noticed in the literature that nanofluids with oxide nanoparticles and carbon nanotubes are produced well by the two-step method, while it is not suitable for nanofluids with metallic nanoparticles. The summary of results reported by various researchers in the area of nanofluid preparation is provided in Table 2.1

Table 2.1.Summary of researches of heat pipes using nanofluids

Year	Researcher	Working fluid	Effect on thermal performance
2010	Guo-shangwang et al.	CuOnanofluid	+
2011	Nandyputra et al.	Al_2O_3	+
2009	Zhen Hua Liu et al.	CuO	+
2009	kyuHyung Do	Al_2O_3	+
2014	Omer A.Alawi et al.	Various	+
2007	Shung wen kang et al	Silver (Ag)	+

3. HEAT TRANSFER CHARACTERISTICS OF NANOFLUIDS IN HEAT PIPES

Many researchers have reported experimental studies on the thermal conductivity of nanofluids in heat pipes, thermal resistance and thermal efficiency of heat pipe. The heat pipe thermal efficiency can be calculated from the ratio of cooling capacity rate of water at the condenser section and supplied power at the evaporator section. The results from all the available experimental studies indicated that nanofluids containing a small amount of nanoparticles have substantially higher thermal conductivity than those of base fluids and also there is an increase in the thermal efficiency of heat pipe.

Nandy Putra et al. investigated the enhancement of screen mesh wick heat pipe thermal efficiency with Al2O3–water, Al2O3–ethylene glycol, TiO2–water, TiO2–ethylene glycol nanofluids. The test section is fabricated from the straight copper tube with the outer diameter 8 mm and length 200 mm. In this, working fluids of heat pipe such as deionized water, alcohol, and nanofluids (alcohol and TiO2 nanoparticles) are tested. The diameter of TiO2 nanoparticles with 21 nm are used, in which the mixtures of alcohol and nanoparticles are prepared using an ultrasonic homogenizer. The parameters considered are the effects of percentage charge amount of working fluid, percentage nanoparticle volume concentrations, and heat pipe tilt angle on the thermal efficiency of heat pipe. The nanoparticles added with the base fluid have a significant effect on the enhancement of thermal efficiency of heat pipe. The thermal efficiency of heat pipe is 10.60% higher than the base working fluid, with 5% nanoparticle volume concentration.

4.RESEARCH ON DEVELOPMENT OF NANOFLUIDS

1.Potential Applications Of Nanofluids

There is great industrial interest in nanofluids. Since the appearance of an article on nanofluids in ANL's "Tech Transfer Highlights" (Zussman, 1997), more than 20 companies have contacted AN], showing great interest and suggesting future interactions involving a number of possible applications of nanofluids. These companies include both heat transfer fluid manufacturers and end users. As a further indication of the potential impact of nanofluids technology on industry, the November 1997 issue of "High-Tech Materials Alert" by John Wiley & Sons, Inc., featured ANL's nanofluids project on page 1 (Katz, 1997). Also, an article on heat transfer fluids, including nanofluids, has appeared in the September 1998 issue of Chemical Engineering magazine (read by more than 100,000 chemical engineers and allied professionals globally) (Shanley, 1998). This great industrial interest shows that nanofluids can be used for a wide variety of industries ranging from transportation, HVAC, and energy production and supply to electronics, textiles, and paper production. All of these industries are limited by heat transfer and so have a strong need for improved fluids that can transfer heat more efficiently.

2 Potential Benefits of Nanofluids

The impact of this new heat transfer technology is expected to be great, considering that heat exchangers are ubiquitous in all types of industrial applications and that heat transfer performance is vital in numerous multibillion-dollar industries. There is now great industrial interest in nanofluids. Some of the specific potential benefits of nanofluids are described below.

2.1 Improved Heat Transfer and Stability:

Because heat transfer takes place at the surface of the particle, it is desirable to use a particle with a large surface area. Nanoparticles provide extremely high surface areas for heat transfer and therefore have great potential for use in heat transfer. The much larger relative surface areas of nanophase powders, when compared with those of conventional micrometer-sized powders, should markedly improve the heat transfer capabilities and stability of the suspensions.

2.2 Reduced Pumping Power:

In heat exchangers that use conventional fluids, the heat transfer coefficient can be increased only by significantly increasing the velocity of the fluid in the heat transfer equipment. However, the requited pumping power increases significantly with increasing velocity. For a nanofluid flowing in the same heat transfer equipment at a fixed velocity, enhancement of heat transfer due to increased thermal conductivity can be estimated. For example, to improve the heat transfer of a conventional fluid by a factor of 2, pumping power must be increased by a factor of about 10. However, if a nanoparticle-based fluid with a thermal conductivity =3 times that of a conventional fluid were used in the same heat transfer equipment, the rate of heat transfer would be doubled (Choi, 1995). Therefore, the potential savings in pumping power is significant with nanofluids.

5.CHALLENGES FOR NANOFLUID BASED HEAT PIPE

Recent and existing studies have mainly showed positive effect of applying nanofluids in heat pipes by enhancing the heat transfer characteristics of heat pipes.As reveled by result of model in this study and other studies ,the thermal conductivity in heat pipes increases with nanofluids applied as working fluids.

Experiment and research have discovered a sediment layer after beingheated.Thiseffect,as mentioned earlier,thermal performances of heat pipes both positively and negatively (Liu and Li,2012).Current studies are focused on how the thermal performance will be affected if the sediment layer Becomes thicker and if the sediment layer will maintain a certain thickness during the entire operation since this has significant impact on practical engineering application of nanofluids in heat pipe .Another field study for improving the thermal performance of heat pipe is the operating temperature Liu et al.have shown the significance of operating temperature on the heat transfer enhancement of nanofluids in several kinds of heat pipes.Recent experiment on closed two-phase thermosyphon,which are gravity driven heat pipes ,carried out by Liu et al.showed that a better heat transfer enhancement was not obtained with a higher operating temperature ,but a lower operating temperature.
Current research are focused on the application of nanofluids in heat pipe by trying to find the optimal types of nanofluids,nanopartical size and shaped ,and nanopartical concentration in order to maximize the thermal performance.other research are carried to find the impact various operating parameter such as,operating temperature,thermal resistnce,viscosity,the heat flux and thermal conductivity.Another difficulty encountered in nanofluid synthesis is the tendency of nanoparticals to aggolomerate into larger particles which limits the benefits of the high surface between the nanoparticals To cope with this issue,particle dispersion additive are most of the time added to the base fluid when the nanoparticles are dispersed .However ,this practice has tendency to change the surface properties of the particles,and the nanofluid may contain a significant amount of impurities that affect the thermal performace of nanofluids.

CONCLUSION

1 .Nanofluids containing small amount of nano particles have higher thermal conductivity than those of base fluids.
2. The thermal conductivity enhanc ement of nanofluids depends on the particle volume fraction, size, type of base fluids and nanoparticle.
The result of heat transfer characteristics of various types of heat pipe by using nanofluid as working fluids.Result of the limited number of available reference have shown that nanofluids have great application prospect invarious heat pipes. For the majority of micro-grooved heat pipe mesh wick heat pipes,oscillating heat pipes and most closed two-phase thermosyphon ,adding nanoparticles to the working liquidean significantly enhance the heat transfer ,reduce the total heat resistance and increases the maximum heat removal capacity.

REFERENCE

1.Zhen – Hue Liu, Yuan –Yang Li, Rambo, 2015. "Thermal performance of inclined grooved heat pipes Using nano fluids", ELSEVIER International Journal of Thermal Sciences, 49: 1680-1687.
2.Kyu Hyung Do, Sung Jin Kim, Suresh V. Gabriella, 2008." A mathematical model for analyzing the Thermal characteristics of a flat micro heat pipe with a grooved wick", Elsevier, International Journal of Heat And Mass Transfer, 51(19-20): 4637-4650.
3. X.F. Yang, Z. Liu, J. Zhao, Heat transfer performance of a horizontal microgrooved heat pipe using CuO nanofluid Journal of Micromechanics and Microengineering .

4.shung-wen kang a,wei-chiang weiet al, Experimental investigation of nanofluids on heat pipe thermal performance,applied thermal engineering 29(2009)973-973.
5.Z.H. Liu, J.G. Xiong, R. Bao, Boiling heat transfer characteristics of nanofluids in a flat heat pipe evaporator with micro-grooved heating surface, International Journal of Multiphase Flow 33 (2007) 1284-1295.
6. S.W. Kang, W.C. Wei, S.H. Tsa, S.Y. Yang, Experimental investigation of silver nano-fluid on heat pipe thermal performance, Applied Thermal Engineering 26 (2006) 2377-2382.