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Enhancement of thermal performance of thermosyphon heat pipe using nano-fluid

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ABSTRACT

The investigation of thermosyphon heat pipe and their application into thermal engineering are known for years, with compact devices and for efficient performance of that devices it's needed to remove heat from the devices at much faster rate than present one. In the present work thermosyphon heat pipe with base fluid as multiwalled carbon nanotube (MWCNT) DI water and DI water is investigated experimentally. The optimum filling ratio for nano-fluid also determined.It is proposed to the effect of MWCNT on the performance of thermosyphon heat pipe. It is expected that there is reduction in thermal resistance due to brownien motion of nanoparticles which improves the conductive as well as convective heat transfer in the system and also works under more heat lode than DI water.

***Keywords*— CNT, MWCNT, Nano-fluid, nano particles, Thermosyphon heat pipe.**

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I. INTRODUCTION

The investigation of thermosyphon heat pipes and their applications into thermal engineering are known for years, being used in various applications, such as heat exchangers, electronics cooling, chemical engineering, waste heat recovery, power generation, air conditioning systems, water heater, and solar collectors. Thermosyphon heat pipes are passive heat transfer devices with high effective thermal conductivity. The effective coefficient of thermal conductivity of a thermosyphon heat pipe can be orders of magnitude higher than that of highly conductive solid materials, such as copper.[1]Common fluids such as water, ethylene glycol, and heat transferoil play an important role in many industrial processes suchas power generation, heating or cooling processes, chemicalprocesses, and microelectronics. However, these fluids have relativelylow thermal conductivity and thus cannot reach high heatexchange rates in thermal engineering devices. A way to overcomethis barrier is using ultra-fine solid particles suspended incommon fluids to improve their thermal conductivity. The suspensionof nano-sized particles(1–100 nm) in a conventionalbase fluid is called a nanofluid.[2]In recent years, many researchers have investigated the effectsof nanofluids on the enhancement of heat transfer in thermalengineering devices, both experimentally and theoretically.Researchers have also applied a variety of preparation methods,characteristics, and different models used for the calculation ofthermophysical properties of nanofluids (i.e., thermal conductivity,viscosity, density, specific heat capacity).The aim of the project is to investigate the heat transfer enhancement by thermosyphon with base fluid as multiwalled carbon nanotubes (MWCNT) DI water and DI water is investigated experimentally for increasing the heat transfer rate & achieving higher efficiency in the application of heat exchanger, nuclear reactor, solar heaters, gas turbine, combustion chamber, electronic component and many other practical heating devices. It is proposed to estimate the effect of MWCNT nanfluids on the performance of thermosyphon heat pipe. It is expected that there is reduction in thermal resistance and work under more heat load than DI water.

II. LITRATURE REVIEW

S.M.S. Murshed, K.C. Leong et al. [1]Review of Impact and potential benefits of nanofluids,Potential applications of nanofluids,Synthesis of nanofluids, various thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity. They also studied theoretical mechanism for the enhanced thermal conductivity of nanofluids. They got the thermal conductivity of various nano particles and their comparative performance.Maryam Shafahiet al [2] Studied effect of Al_2O_3, CuO and TiO_2nanofluids on the performance of heat pipe. They reported the substantial changes in heat pipe thermal resistance,temperature distribution, and maximum capillary heat transfer of the heat pipe is observed when using a nanofluid.The nanoparticles within the liquid enhance the thermal performance of the heat pipe by reducing the thermal resistance while enhancing the maximum heat load which it can carry. It is found that smaller particles have a more pronounced effect on the temperature gradient along the heat pipe. Also the existence of an optimum mass concentration for nanoparticles in maximizing the heat transfer limit is established.Gabriela Huminic et al [3]studied experimentally the effect of Iron Oxide nanoparticles on the performance of thermosyphon heat pipe. While experimentation studied the temperature distribution and compare the heat transfer rate of the thermosyphon heat pipe with nanofluid and with DI-water. Also tested various concentration levels of nanoparticles. Rresult shows that thermal performance increases with increase in particle concentration.MostafaKeshavarzMoraveji et al [4]Studied the effect of using aluminum oxide nanofluid on the thermal efficiency enhancement of a heat pipe on the different operating state was investigated The tested concentration levels of nanofluid are 0%, 1% and 3%wt. Resultsshow that by charging the nanofluid to the heat pipe, thermal performance is enhanced by reducing the thermal resistance and wall temperature difference. The thermal efficiency of heat pipe charged with nanofluid is compared with pure water.Matthias H. Buschmann et al [5]reviewed the application of nano fluid in thermosyphons, heat pipes, and oscillating heat pipes. He found that pipes Performance effects which are related to filling ratio, inclination angle, and operation temperature seem to be similar to those for classical working fluids. Decrease of the thermalresistance or an increase of the efficiency with increasing concentration, but also a reversing of this trendif a certain optimal concentration is exceeded. The main mechanism responsible for the improved thermal performanceseems to be a porous layer built from nanoparticles on the evaporator surface. Additional positiveeffects may follow from the changed thermophysical properties of the working fluid.PaisarnNaphon et al [6]He found that Effects of % charge amount of working fluid, heat pipe tilt angle and % nanoparticles volume concentrations on the thermal efficiency of heat pipe are considered. The nanoparticles have a significant effect on the enhancement of thermal efficiency of heat pipe. The thermal efficiency of heat pipe with the nanofluids is compared with that the based fluid.RichaRastogi et al [7] She studied comparatively dispersion of multiwalled carbon nanotubes(MWNTs) with four surfactants—Triton X-100, Tween 20, Tween 80, and sodium dodecyl sulfate (SDS).Among the four surfactants, Triton X-100 and SDS provide maximum and minimum dispersion, respectively. An optimumCNT-to-surfactant ratio has been determined for each surfactant. This parameter is shown to affect thenanotube dispersion significantly. Surfactant concentration above or below this ratio is shown to deterioratethe quality of nanotube dispersion. Temperature stability of the surfactant is another importantfactor affecting the quality of CNT dispersion.ParitoshGarg et al [8]He studied the effect of dispersing energy (ultrasonication) on viscosity, thermal conductivity, and the laminar convective heat transfer was studied. Results indicate that thermal conductivity and heat transfer enhancement increased until an optimum ultrasonication time was reached, and decreased on further ultrasonication. The maximum enhancements in thermal conductivity and convective heat transfer were found to be 20% and 32%, respectively. From results it is found that the 40 min. ultrasonication is optimum time of sonication for obtaining the maximum thermal conductivity.Pravin R. Harde et al [9] He found that performance of solar water heater enhances due to the nano fluid. Thermal resistance of thermosyphon decreases with increase in the nano particle concentration.

III. NANOFLUID

The MWCNT is having higher thermal conductivity. Which can be seen from fig.1

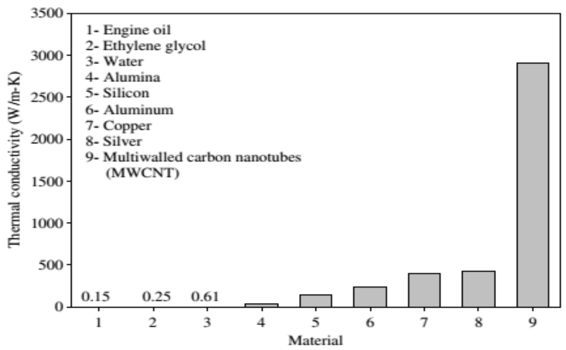

Fig.1Thermal conductivity of typical materials (solids and liquids) at 300 K

Nanoparticles used for experimentation are MWCNT which are purchased from Global Nanotech,Goregoan, Mumbai.

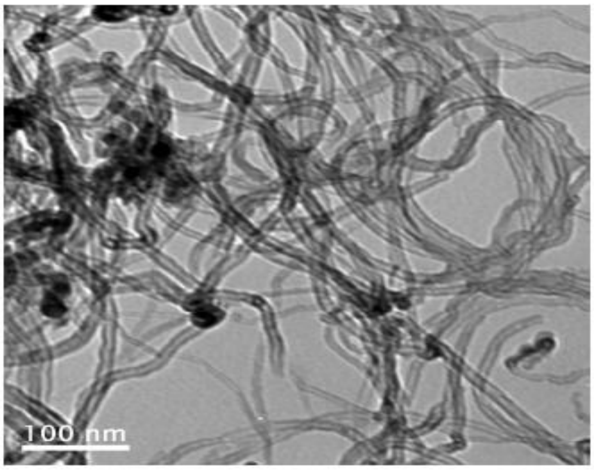

Fig.2 TEM image of MWCNT

Thermal conductivity of nanofluid is calculated with help of following formula.

$$K_{nanofluid} = \frac{1-\emptyset+2\emptyset\frac{K_p}{K_p-K_b}\ln\frac{K_p+}{2K}}{1-\emptyset+2\emptyset\frac{K_b}{K_p-K_b}ln\frac{K_p+}{2K}}$$

Where,
Φ= volume fraction of nanoparticles in suspension
kp = thermal conductivity of nanoparticle.
Kb = thermal conductivity of base fluid.

The theoretically obtained thermal conductivity of nanofluid for particle concentration 0.15% wt is 3.5744W/mK which is greater than thermal conductivity of DI water 0.613W/mK. That is the first parameter which will cause the thermal enhancement.

IV. Conclusions

The work which is carried out up till now shows that the use of nanofluid in thermosiphon enhances the themal performance. The possible cause to enhancement are as follow

- Ballistic conduction.
- Brownian motion.
- Organized structure.
- Micro-convection

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