Improve The Thermal Performance of Heat Pipe Using Nano-fluid

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ABSTRACT-**Nano fluid is new type of working fluid with unique properties to improve the heat transfer of heat pipe. Miniaturization and increased operating speeds of devices warranted the requirement for new and innovative cooling concepts for good performance. The less thermal conductivity of conventional heat transfer fluid has been a serious hindrance for getting better the performance and compactness of engineering equipments. These problems are resolved by using nano meter size particles. In recent years three of the most common nano particles are Al2O3, CuO and TiO2 are considered. This review paper and summarises the study done on heat pipe using nano fluid as working fluid.**

KEYWORDS-**Nanofluid, Heatpipe, Heat transfer improvement, Thermal conductivity.**

I. INTRODUCTION

A heat pipe is simple equipment that can rapidly move heat from one point to another. They are frequently called the "superconductors" of heat as they have an extra ordinary heat transfer capacity and rate with almost no heat loss.

A heat pipe is a closed evaporator-condenser system consisting of a seal, hollow tube whose inside walls are covering with a capillary structure or wick. Thermodynamic working fluid, with substantial vapour pressure at the desired operating temperature, penetrated the pores of the wick. When heat is applied to the heat pipe, fluid in the pipe heats and evaporates. As the evaporating fluid fills the hollow centre of the wick, it diffuses throughout the heat pipe. Condensation of the vapour occurs wherever the temperature is even little below that of the evaporation area. As it condenses, the vapour gives up the heat it acquired during evaporation. This effective thermal conductance helps maintain constant temperatures.

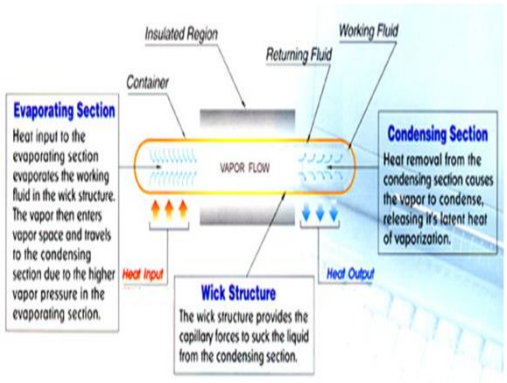


Figure 1: Working principle

The thermal conductivity of the working fluid limits the heat pipe performance and it is thus chosen according to the temperatures, at which the heat pipe must operate. One of the most advanced methods to improve the thermal conductivity is the dispersion of nano-scale solid particles into plane fluid's a new kind of heat transfer working fluid, the nano fluid is a technology attempt to use the special property of this functional fluid to improve the phase-change heat transfer in heatpipes, and will have wide application prospect.

II. DEFINITION OF NANOFLUID

Fluids have been utilized as a working fluid for cooling intention includes engine oil, water and ethylene glycol. These fluids have low thermal conductivity than metals and ionic component like: copper, silver, silicon carbide and copper oxide. The exclusive of these metals and ionic components increase to a fluid that consisted of a combination of a base fluid and metals, initiated by Maxwell. This concept of a suspension, led to the enhancement in one of the most crucial parameters in a working fluid: thermal conductivity. A suspension is a heterogeneous combination in which solute like particles arrange of a solvent-like phase.

Choietai defined the nano fluids as "an innovative new group of heat transfer fluids that can be engineered by suspending nano particles in conventional heat transfer fluids" whereas nano-sized particles of 1-100 nm were joined to base fluids in order to enhance performance of heat transfer by importantly enhancing the thermal conductivity of the fluid. The advantages of nano fluids in comparison to microfluids have been experiment and it is establish that nanofluids possess longer suspension time, higher thermal conductivity and are more energy effective. Increasing thermal transport properties of nano fluids has been claimed to be vital for gaining a higher heat exchanging efficiency, cost reduction and reducing the system size.

Nano particles exist in form of metals, metal oxides and carbon materials. They are of diverse morphological signature and appear as spheres, cylinders, disks etc. The thermal conductivity of nano particles is generally up to hundred times larger than base fluids. For example, non-metallic solids like diamond have a thermal conductivity if 3300 W/mK although non-metallic liquids like water have a thermal conductivity of 0,613 W/mK. In addition to thermal conductivity, there are three other parameters affecting nanofluids: specific heat capacity, dynamic viscosity and density . However, they are not included in the scope of this report and therefore not deeply discussed.

MATERIALS USED FOR NANOPARTICLES AND BASIC FLUIDS

- *NANOPARTICLE MATERIALS INCLUDE*

- Oxide ceramics – Al2O3, CuO
- Metal carbides – Sic
- Nitrides – AlN, SiN
- Metals – Al, Cu
- Non-metals – Graphite, carbon nanotubes
- Layered – Al + Al2O3, Cu + C

- *BASE FLUIDS INCLUDE*

- Water
- Ethylene and other coolants
- Oil and other lubricants
- Bio-fluids
- Polymer solution

CREATION OF NANOPARTICLES

The preparation procedure and synthesis of nanofluids is a vital process to obtain better performance of nanofluids and improved thermal transport properties. It is important to achieve homogenous suspensions in order to optimize thermophysical properties of nanofluids. Current scientific experiments and researches are focusing on improving the thermal conductivity by considering the effective parameters of thermal conductivity and predicting the behavior of nanofluids . Substances, also known as additives, are used to prepare nanofluids by utilizing base fluids and nanoparticles in order to increase the stability and enhance the performance of the dispersion of nanofluids.

The production process of nanoparticles is divided into two approaches: top- and bottom-down synthesis of nanomaterial and fabrication of nanostructures . The top down approach involves the process of breaking down bulk material into nano-sized particles and structures. The approach is an extension of methods that have been used for producing micro-sized particles, considered more suitable for creating cohesive structures. Mechanical size reduction such as grinding and milling are examples of top down approaches. The more economical alternative, the bottom up approach, refers to a controlled assembly process in the build-up of a material, using atom-by-atom, or molecule-by-molecule procedures. This method is preferable for creating identical structures with atomic precision.

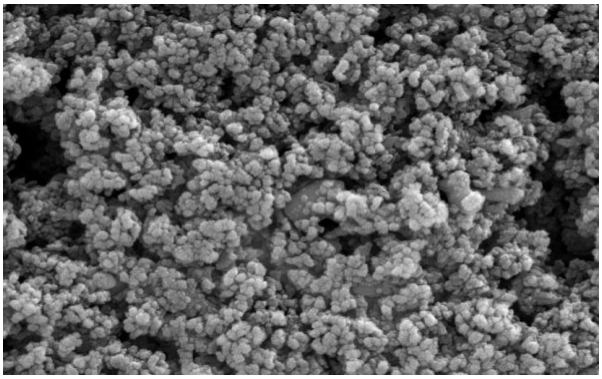


Figure 2: Nano particle of Al_2O_3

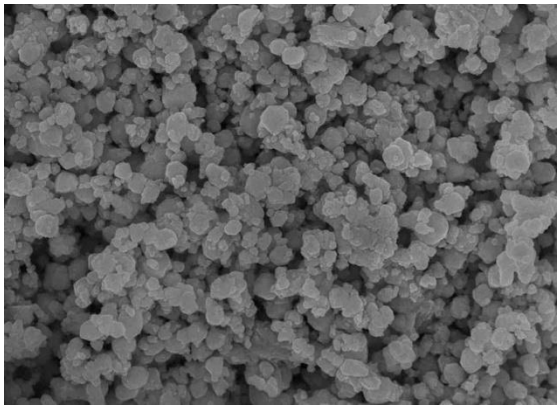


Figure 3: Nano particle of CuO

THERMAL CONDUCTIVITY OF NANOPARTICLES AND BASE FLUIDS

The heat transfer performance of a heat pipe is related to the thermo physical restrictions of the working fluid. Thermo physical Limitation on the unlike depend mainly on the thermal conductivity of the working fluid. Thermal conductivity example the ability of a material to conduct heat. The higher the thermal conductivity of the fluid the more effective is the heat transfer capability of heat pipe.

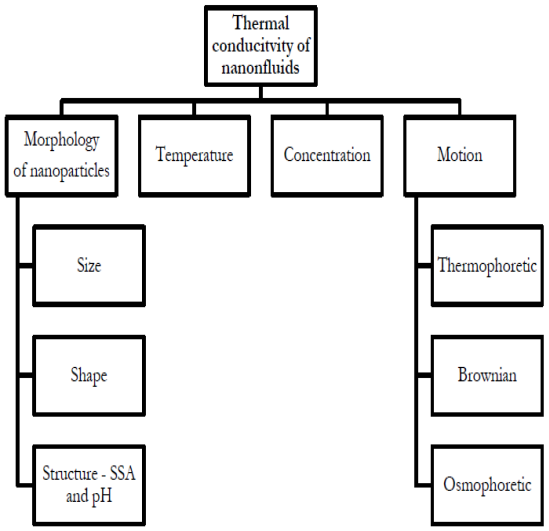
In order to enhance the thermal conductivity, highly conductive solid nanoparticles can be added to a base fluid e.g. water, ethylene glycol or pump oil . The result is a nanofluid i.e. a colloidal suspension of solid particles with the size lower 100 nanometers. the variance in thermal conductivity from base fluids (non-metallic liquids) to nanofluid solid particles (metallic solids) which are generally over hundreds times more conductive .

Solid/Liquid	Material	Thermal Conductivity (W/mK)
Metallic solid	Silver	429
	Copper	401
	Aluminum	237
Non-metallic solids	Diamond	3300
	Carbon nanotubes	3000
	Silicon	1458
	Aluminum oxide (Al_2O_3)	40
Metallic liquids	Sodium @ 644K	72,3
Non-metallic liquids	Water	0,613
	Ethylene glycol	0,253
	Engine oil	0,145

Table1: Thermal conductivity of nano particles

PARAMETERS AFFECTING THE THERMAL CONDUCTIVITY OF NANOFLUIDS

Parameters affecting the thermal conductivity of the nanofluid are: morphology, temperature, concentration and motion of nanoparticles . Each parameter will be deliberated in the proceeding text.



3. Parameters affecting the thermal conductivity of nano fluids

- *MORPHOLOGY OF NANOPARTICLES*

Morphology is by biologists describes as the study of the size, shape and structure of organisms and the relationship of the parts including them. Research done by Li et al. has shown that nanofluids with smaller nanoparticles enhance the thermal conductivity. In this particular experiment aluminum nanoparticles of diameter 36 and 47 nm were used in the same base fluid. Experiments were performed between the temperature 27 - 37 ℃ witch volume fractions between 0.5 - 6 %. The result was an 8 % higher thermal conductivity for nanofluids with the 36 nm particles i.e. the smaller particles.

- *TEMPERATURE*

Research done by Yu et al. confirms that a small increase of thermal conductivity with higher temperature of nanofluids higher temperature of nano fluid increases its thermal conductivity more than three times.

- *MOTION*

Wang et al. firstly discussed the effect of motion of the nanofluid related to its thermal conductivity. Motion of particles causes a temperature gradient

in the fluid referred to as the thermophoretic motion. Brownian motion of the nanoparticle, which some researchers believe to be an important parameter resulting in the increase of the thermal conductivity of the nanofluid. Brownian motion occurs when nanoparticles collide with water molecules in base fluids.

- *CONCENTRATION*

The concentration of particles has been proven to be essential for the thermal conductivity of the nanofluid. Eastman et al. conducted research where they added copper (Cu) nanoparticles of mean diameter smaller than 10 mm, in the base fluid ethylene glycol. With Cu concentration of approximately 0.3 % the thermal conductivity of the ethylene glycol i.e. the nanofluid increased with 40% .

ADVANTAGES OF NANOFLUID

- High specific surface area due to this more heat transfer surface between atoms and fluids.
- High dispersion equilibrium with predominant Brownian movement of particles.
- Decrease pumping power as compared to pure liquid to accomplish equivalent heat transfer intensification.
- Decrease particle trammel as compared to conventional slurries, therefore promoting system miniaturization.
- Adjustable properties, such as thermal conductivity and surface wet ability, by varying particle concentrations to suit different applications**.**

CONCLUSION

Nanofluids are important because they can be used in numerous applications involving heat transfer, and other applications such as in detergency. The thermal performance of heat pipes utilizing a nano fluid as the working fluid has been investigated. Three of the most common nano particles, namely Al2O3, CuO, and TiO2 are considered.

Further research still has to be done on the synthesis and applications of nanofluids so that they may be applied as predicted. Nevertheless, there have been many discoveries and improvements identified about the characteristics of nanofluids in the surveyed applications and we are a step closer to developing systems that are more efficient and smaller, thus rendering the environment cleaner and healthier.

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