A Review Paper on Assessment of Thermal Performance of Heat Pipe by Using Nanofluid

S. M. Sakhare-Chougule[1], S. H. Sarje[2]
PG Student[1], PG Guide[2]
[1, 2] JSPM's Imperial College of Engineering & Research, Wagholi, Pune-14, India.

Abstract: Nanofluids have found a very crucial role in heat transfer than available fluids like water and oil in accordance to reduce cost and size of heat exchanger. The modern nanotechnology developed nanoparticles in last few years. These nanoparticles have unique thermal and electrical properties. Due to this heat transfer rate has been enhanced. The heat pipe has been used to transfer heat from one region to another region of any system. The heat pipe have an extremely high thermal conductance in steady state operation as compared to other device of heat transfer. The nanofluids can significantly enhance heat transfer rate in heat pipe so that efficiency and thermal performance of heat pipe will be increased. This paper reviews the preparation, characterization, stability of nanofluid and concept, working, applications of heat pipe.
Keywords: Nanofluid, Characterization, Stability, Heat pipe, Thermal performance.

1. INTRODUCTION

Now days heat transfer has got very importance in thermal engineering. It requires a wide research and study. The main focus has to increase heat transfer rate through minimum area with optimum cost. One of the most common heat transfer device has heat pipe. Heat pipe finds its applications in number of areas such as air conditioning system, designing compact electronic components, solar energy, space applications, waste heat recovery system, food industry, telecommunication, geothermal system etc. As per as applications of heat pipe concerns light weight and high performance have main objectives of current heat pipe. The crucial consideration in designing heat pipe has to select appropriate heat transfer fluid. A new emerging branch nanotechnology has found its application in heat transfer field. Nanofluid is the mixture of base fluid and nanoparticles. The nanoparticles are freely suspended in base fluid. Nanofluids have better thermal conductivity than its base fluid. Due to this nanofluid has become a promising thermal fluid for heat transfer.

2. PREPARATION OF NANOFLUID

The nanofluids have prepared by different methods. In single step method nanoparticles has manufactured and dispersed in base fluid in one step. The different techniques have used for preparation of nanofuid in this method such as vacuum evaporation onto a running oil substrate, microwave irradiation and vacuum based submerged arc nanoparticle sysnthesis. The merit of this method has agglomeration of nanoparticles in the fluid has minimized. The demerit of this method has a residue reactant left behind due to incomplete reaction which diminishes the purity of nanofluid.

In two step method nanofluids have prepared in two steps. In first step nanoparticles have manufactured by physical, chemical, mechanical or any other means. In second step nanoparticles have dispersed in the base fluid. The proper and homogeneous mixture of nanoparticles in the base fluid has done with the help of ultrasonic vibrator, higher shear mixing device, ball milling or intensive magnetic force agitation. This method more suitable for nanofluids containing oxides of metal. In this method agglomeration of nanoparticle may occur, still due to simplicity this method mostly used to prepare nanofluids.

3. CHARACTERIZATION OF NANOFLUID

For enhancement of heat transfer nanofluids needs to be characterize. The size of nanoparticle, concentration of nanofluid and impurity in nanofluid has found out by using different techniques. Transmission electron microscopy (TEM) technique used to verify single particle dimensions and determine agglomeration of particle in nanofluid. In TEM electron beam has used to find nanometer level. In Dynamic light scattering (DLS) time measurement of scattered light intensity from colloid has used to determine particle size in colloid. Neutron activation analysis (NAA) has used to determine particle concentration and contamination in nanofluid solution with the help of gamma decay emission after neutron irradiation of sample. Inductively coupled plasms (ICP) be the more effective technique for characterization of nanofluid to determine concentration and contamination. ICP uses the light spectrum released from injecting materials into high temperature plasma. Thermogravimetric analysis

(TGA) used to characterize nanofluid by weight. TGA works by heating sample in high temperature furnace and graph weight vs time with boiling point of species gives sample composition.

4. STABILITY OF NANOFLUID

Due to agglomeration of nanoparticles thermal conductivity of nanofluid decreases. For this stability of nanofluid need to be chcked. For checking stability of nanofluid different methods have used. Zeta potntial analysis indicates stability of nanofluid by measuring potential difference between dispersion medium and stationary layer of fluid. Higher potential difference indicates more stability. Sedimentation method gives stability by applying external force on nanofluid to start sedimentation. The weight or volume of sediment gives stability of nanofluid. Spectral Absorbency Analysis (SAA) is the efficient method to check stability of nanofluid. In this method stability has found by using chart UV vs spectroscopy reliability. Centrifugation method gives better results within less time than sedimentation.

Stability of nanofluid can be enhanced by addition of surfactants in the nanofluid. Surfactants minimize the surface tension of base fluid and due to which increase in the immersion of particles. Surfactant can be a chemical compound like Sodium dodecyl sulfate (SDS), salt and oleic acide. Surface modification techniques also enhance the stability of nanofluid. Stability of nanofluid has relation with its electro kinetic properties. Therefore control of pH of nanofluid also increases the stability.

5. HEAT PIPE

Heat pipes have been utilized in heat transfer related applications for many years. Depending on their use, they can operate over a wide range of temperatures with a high heat removal capability. The heat pipe is a device that utilizes the evaporation heat transfer in the evaporator and condensation heat transfer in the condenser, in which the vapor flow from the evaporator to the condenser is caused by the vapor pressure difference and the liquid flow from the condenser to the evaporator is produced by the capillary force, gravitational force, electrostatic force, or other forces directly acting on it. As illustrated in Fig. 1, a typical heat pipe consists of three sections: an evaporator or heat addition section, an adiabatic section, and a condenser or heat rejection section. When heat is added to the evaporator section of the heat pipe, the heat is transferred through the shell and reaches the liquid. When the liquid in the evaporator section receives enough thermal energy, the liquid vaporizes. The vapor carries the thermal energy through the adiabatic section to the condenser section, where the vapor is condensed into the liquid and releases the latent heat of vaporization. The condensate is pumped back from the condenser to the evaporator by the driving force acting on the liquid.

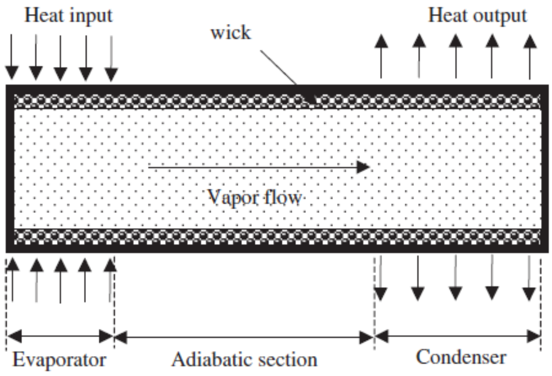

Fig. 1 Schematic of heat pipe.

6. TYPES OF HEAT PIPE

The heat pipe has number of types. Thermosyphon be the simplest form of heat pipe. Thermosyphon has vertical oriented wickless pipe with liquid pool at bottom. It has three sections similar to convectional heat pipe. The loop type heat pipe consist of capillary pumped loop which uses the capillary pressure developed by wick to circulate working fluid in heat pipe. In pulsating type heat pipe expansion and contraction of vapor volume in evaporator and condenser plus thermal energy added in system generates pulsating motion. The micro heat pipes have used in the semiconductor devices to obtain uniform temperature distribution and improve thermal control. Variable conductance heat pipes have suitable for the applications where evaporator and condenser temperature needs to kept constant at variable heat input. In rotating heat pipe centrifugal force causes to return condensate into evaporator and due to rotary motion heat transfer performance has enhanced. The cryogenic heat pipes have used at cryogenic conditions.

7. CONCLUSION

Various types of nano particle with different base fluids has proved its potential to improve thermal properties of working medium in heat pipe. The experimental investigation needed to optimize thermal performance of heat pipe by using nanofluid. Further research is required to obtain simplicity in the use of nanofluid in various applications.

8. REFERENCES

[1] Mohomound Jama, Tejvir Singh, Critical review on nanofluids: Preperations, characterization and applications, *Hindawi Publishing Corporation Journal of Nanomaterials*, Vol 5, pp 1-22, 2016.

[2] Sayantan Mukherjee, Somjit Paria, Preparation and Stability of Nanofluid-A Review, *IOSR Journal of Mechanical and Civil Engineering*, Vol 9, pp 63-69, 2013.

[3] P M Sonawane, M D Shende, V P Baisane, Effect of Nanofluid on Heat Pipe Thermal Performance: A Review of Recent Literature, *International Journal of Engineering and Applied Science*, Vol 3, pp 31-35, 2016.

[4] Paisarn Naphon,, Experimental investigation of titanium nanofluids on the heat pipe thermal efficiency, *International Communications in Heat and Mass Transfer*, Vol 35 , pp 1316–1319, 2008.

[5] A. Walunj, F.Z. Pathan, A.A. Shaikh, A. K. Hussein, Heat transfer enhancement in heat pipe using nanofluid – A review, *International Journal on Theoretical and Applied Research in Mechanical Engineering*, Vol. 4, issue -1, pp 2319-3182, 2015.

[6] Rudresha S, Vijee Kumar, CFD Analysis and Experimental Investigation on Thermal Performance of Closed loop Pulsating Heat pipe using different Nanofluids, *International Journal of Advanced Research*, Vol. 2, Issue 8, pp 753-760, 2014.

[7] Harry O' Hanley, Jacopo Buongiorno, Thomas McKrell, Lin Wen Hu, Measurement and model correlation of specific heat capacity of water based nanofluids with Silica, Alumina and Coper oxide nanoparticles, *ASME International Mechanical Engineering Congress and Exposition*, Vol. 10, pp 1209 – 1214, 2011.

[8] Sheng Qi Zhou, Rui Ni, Measurement of the specific heat capacity of water based Al_2O_3 nanofluid, *Applied Physics Letter*, Vol. 4, pp 48-53, 2008.

[9] Drilon Ferizaj, Mohomad Kassem, Effect of nanofluid on thermal performance of heat pipe, *Bachelor of Science Thesis KTH industrial engineering and management*. Vol. 8, pp 23- 57, 2014.

[10] Wei Yu, Huaqing Xie, A review on nanofluid: preparation, Stability mechanism and applications, *Hindawi Publiahing Corporation Journal of Nanomaterials*, Vol. 18, pp 17, 2012.