A Detailed review On: Thermal Performance of Heat Pipe Charged with Nano Fluid

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Abstracts
In This article gives a comprehensive review about the latest advances related with the application of the Nano fluid in the heat pipe. Papers reviewed including theoretical, numerical and experimental up to date works interrelated with the Nano technology. Heat transfer in heat pipes using suspensions of nanometre-sized solid particles in base fluids have been experimentally and theoretically investigated in recent years by various researchers across the world. It was found that the use of the Nano fluid in the heat pipe can play a substantial role in increasing the efficiency of these devises. The objective of this paper is to present an overview of literature consisting with recent developments in the study of heat transfer using Nano fluids in heat pipes and some important inferences from the various papers are also highlighted.

Keyword: Nano fluid, heat transfer rate, heat pipe, thermal resistance

1. Introduction

The heat pipe was first established in 1942 by g. Richard a general motor engineer. Heat pipes are efficient heat transfer devices with minor temperature drops laterally the heat pipe. The heat transport capability of the heat pipe is organized by the thermo-physical properties of working fluids [1].heat pipes, which are well observed as “super thermal conductors” and frequently the primary components of a heat transfer arrangement, have been generally used in thermal devices and mechanisms for their operative cooling and thermal controlling. The uses of heat pipes can be seen in several industrial areas such as the electrical and electronic, aerospace, telecommunications, food industries, etc. Over the past spans, much attention has been paid to the enhancements of heat pipes including the appearance, design and optimisation, diminishment and weight decline, and towards achieving higher heat flux above the past era, heat pipe use in electronic cooling applications has better histrionically, primarily in notebook computers. In circumstance, nearly every notebook computer manufactured today uses at lowest one heat pipe assembly typically designed to carry less than 20 w of power these parts are small in cost and are highly reliable. Heat pipe use in high-power cooling applications has been limited to custom applications requiring either low thermal opposition or with a severely restricted enclosure area. The cost of these larger diameter heat pipes is extraordinary due to a limited number of manufacturers and handmade assembly with the advancement in nanotechnology and thermal engineering, several efforts have been devoted to heat transfer improvement. The usual improvement techniques for heat transfer can scarcely meet the ever growing demand of heat removal in high energy devices. However, out-dated fluids have poor heat transfer properties compared to best solids. Therefore, Argonne national laboratory has developed a new class of heat transfer fluids called ‘‘Nano fluids’’, which are engineered by suspending ultra-fine metallic or non-metallic nanometre dimension particles in traditional fluids, such as water, engine oil, and ethylene glycol[2]. And the wick is very essential cog in the heat pipe. Every investigator concentrates on the design of wick structure. There are several categories of wicks are used in this field, some of them are axial grooved wick, mesh wick, and wire bonded wick, two layer composite wick, and sintered wick. In furthermost of the research work screen mesh wick is used by the researchers. At the same structural porosity, the more and smaller pores produce more interaction boundaries between working fluid and solid structures, thus promoting the length and total area of thin film instantaneously. The sintered powder structures provide many minor pores, which characteristic is related to powder parameters and sintering processes. Because these small pores occur, the mechanism of thin-film evaporation occurs obviously in sintered powder structures. The characteristics of higher fluid pumping effect and lower conductive thermal resistance also show that sintered powder structures are suitable to be used as the wick structure of heat pipes [3].

1.1GENERAL MECHANISM OF HEAT PIPE

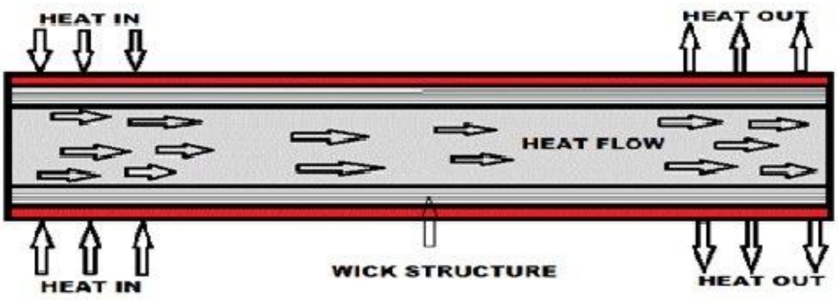


Fig.1 simple construction of heat pipe

A heat pipe is a high heat flux, passive heat transfer device which uses the evaporation, condensation, and surface tension of a working fluid to attain an extremely high thermal conductivity. Broadly speaking, in terms of a heat pipe, the vapour flow from the evaporator (hot side) to the condenser (cold side) is caused by the vapour pressure difference. Meanwhile the liquid flow from the condenser (cool side) to the evaporator (hot side) is produced by the forces, such as capillary force, gravitational force, electrostatic force, or other forces directly acting on it. Regardless of the orientation of the heat pipe (vertical or horizontal, for example), the basic principles are the same. Therefore, a simple horizontal heat pipe is in use as the case in point in order to explain the principle.

1.2 CLASSIFICATION OF HEAT PIPES

As regards the categorizations of heat pipes, under the different conditions, they can be divided into different Kinds which might depend on the geometries applications According to literature [4], there are two primary methods to categorize the heat pipes? These are based upon the functioning fluids' operating temperatures, and the types of control. For every one heat pipe use, there will be a temperature range for its specific operating conditions. Therefore, choosing a appropriate working fluid is necessary, which not only considers the operating temperature (along with the pressure condition), but also concerns the compatibility with heat pipe container and wick materials. Based on the operating temperature, the heat pipes can be classified by the following four different types[5].

TYPE	TEMPRETURE RANGE	SPECIFICATION
High temperature	>700 K	Using liquid metals, very high heat fluxes can be obtained due to the inherent properties Of the fluid, namely, very large surface tensions and high latent heats of vaporization. Copper, silver and aluminium are the examples of commonly used liquid metals.
Medium temperature	550-700K	Some special organic fluids, such as naphthalene and biphenyl can be used for medium temperature applications
Room temperature	200-550K	The working fluids typically used methanol, ethanol, ammonia, acetone, and water
Cryogenic (low Temp.)	1-200K	With working fluids such as helium, argon, neon, nitrogen, and oxygen. Due to very low values of the latent heat of vaporisation, and low surface tensions of the working fluids, they usually have relatively low heat transfer capabilities

2. LITERATURE REVIEW

Wen Kang et al. conducted a study to Nano-fluid is employed as the working medium for a conventional 211lm wide · 217 lm deep grooved circular heat pipe. The Nano fluid used in this study is an aqueous solution of 35 nm diameter silver Nano-particles. The experiment was done to measure the temperature distribution and to associate the heat pipe thermal resistance using Nano-fluid and DI-water. The tested Nano-particle concentrations ranged from 1 mg/l to 100 mg/l. The condenser section of the heat pipe was attached to a heat sink that was cooled by water supplied from a constant-temperature bath maintained at 40^0C. At a identical charge volume, the measured Nano-fluid filled heat pipe temperature distribution established that the thermal resistance decreased 10–80% compared to DI-water at an input power of 30–60 W. The dignified results also show that the thermal resistances of the heat pipe decrease as the silver Nano-particle size and concentration growth [6].

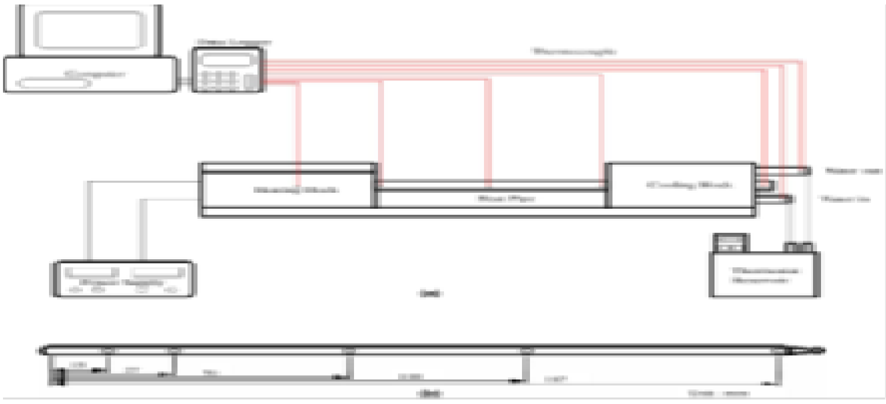


Fig.2

Ghanbarpour et al. done investigational study was accomplished to investigate the thermal performance of heat pipes using Si C water Nano fluid as the functioning fluid. Four cylinder-shaped copper heat pipes containing two layers of screen mesh were fictitious and tested with water and water based Si C Nano fluids with nanoparticle mass concentrations of 0.35%, 0.7% and 1.0% as working fluids. Si C Nano fluids properties and characteristics are evaluated and its effects on thermal performance improvement of screen mesh heat pipes at different concentrations and inclination angles are investigated. Experimental results show that Nano fluid improves the performance of the heat pipes and the thermal resistance of the heat pipe with Si C Nano fluid reductions with increasing nanoparticle concentration. Thermal resistance reduction of heat pipes by 11%, 21% and 30% was observed with SiC Nano fluids containing 0.35 wt.%, 0.7 wt.% and 1.0 wt.% SiC nanoparticles as compared with water. The present investigation indicates that the maximum heat removal capacity of the heat pipe increases by 29% with Si C Nano fluids at nanoparticle mass concentration of 1.0 wt.%[7].

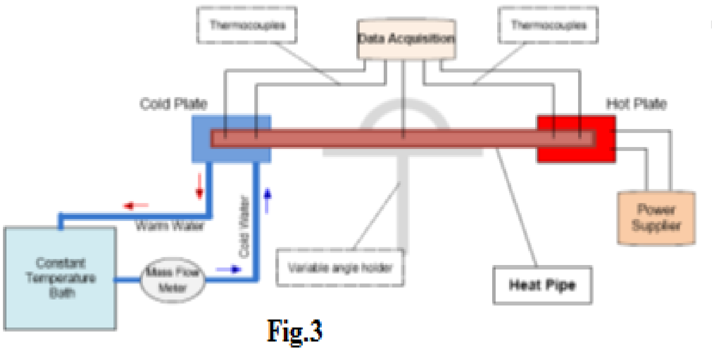


Fig.3

Ahmadi et al. was developed a technique Related to Nano fluids with modification in the structure have engrossed in fluid mechanics. In this work, a double pipe heat exchanger with loaded Al_2O3-TiO_2 hybrid Nano fluid in turbulent flow regimes is studied and evaluated through energy analysis. In order to obtain the energy efficiency of the Nano fluid-loaded double pipe heat exchanger a complete factorial experimental design approach was employed. Nano fluid concentration in the range of 0.2 to 1.5, Reynolds number from 3000 to 12000, and twist ratio between 2 to 8 are considered as the test's variables. It is concluded that applying Nano composites and twisted tapes boost up the exergy efficiency in comparison to utilizing conventional water as a heat transfer fluid. Moreover, rising the nanoparticles volume concentration and the Reynolds number, simultaneous to decreasing the twist ratio can result in higher exergy efficiency [8]

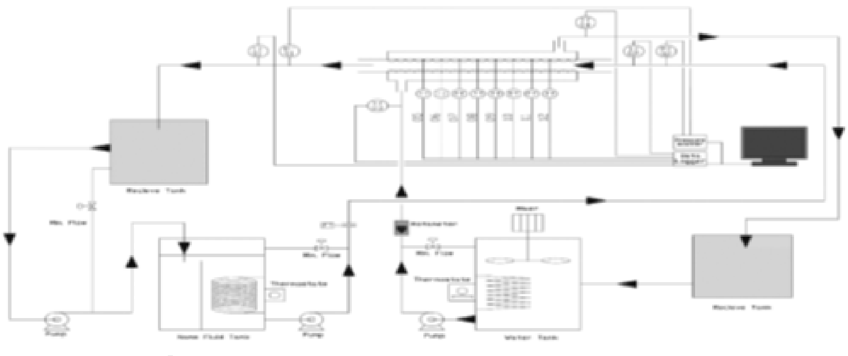


Fig.4

Senthil et al. An investigational on the thermal efficiency and thermal resistance with respect to the inclined angle using heat pipe was carried out. The working fluids used for this are Al_2O_3 Nano fluid and deionized water. The performance of heat pipe in terms of overall heat transfer coefficient and thermal resistance is quantified by varying the volume of working fluid and the performance parameters are contemplated. For this purpose Al_2O_3 Nano particles with a density of 9.8 g/cm^3 and a volume focus of 1% are used as the working fluid in investigational heat pipe. The concert of heat pipe was evaluated by conducting experimentations with different thermal loads and different angle of inclinations. Thermocouples are used to record the temperature distribution across the experiment. Volume of nanoparticles in the base fluid and the consequence of filling ratio on the thermal resistance of the Nano fluids are investigated. The results provide evidence that the suspension of Al2O3 nanoparticles in the base fluid increases the thermal efficiency of heat pipe and can be used in practical heat exchange applications [9].

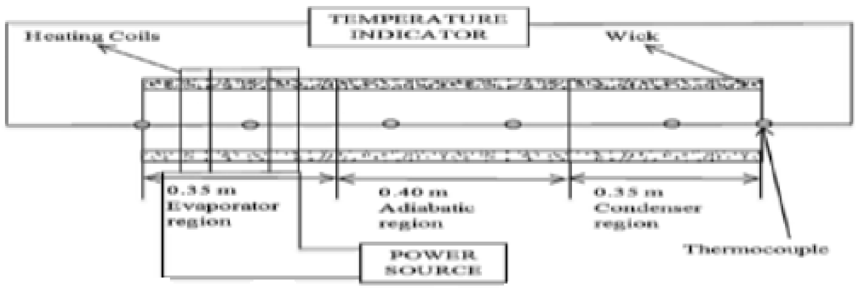
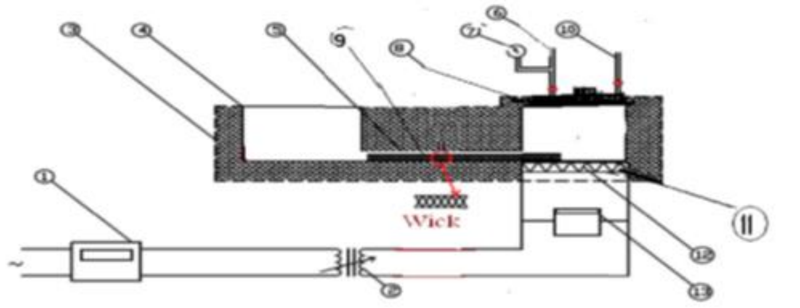


Fig.5

M.G. Mousa. Investigated is to experimentally study the conduct of Nano fluid to improve the performance of a circular heat pipe. Pure water and Al_2O_3-water based Nano fluid are used as Functioning fluids. An experimental setup is designed and constructed to study the heat pipe performance under different operating situations. The effect of filling ratio, volume fraction of nanoparticles in the base fluid, and heat input rate on the thermal resistance is investigated. Total thermal resistance of the heat pipe for pure water and Al_2O_3-water based Nano fluid is also predicted. An investigational correlation is achieved to predict the influence of Prandtl number and dimensionless heat transfer rate, Kq on thermal resistance. Thermal resistance decreases with increasing Al_2O_3 water based Nano fluid compared to that of pure water. The experimental data is compared to the available data from previous work[10].



1. Stabilizer	2. Autotransformer	3. Insulation	4.condenser	5.Adiabatic tube
6. Charge line	7. Pressure gage	8. Evaporator	9-Wick	10. Vacuum line
11. Mica sheet	12. Electric heater	13. Multi-meter		

Fig.6

3. Conclusion

This paper gives a widespread survey about the recent advances related with the application of the Nano fluid in the heat pipe some important conclusions are summarized below:-
1-The future helpfulness must be directed towards the effect of the optical properties of Nano fluid on the performance of Heat pipe together with the other fluid properties except the thermal conductivity.
2-The future works must be directed towards inventing non-toxic and low cost nanoparticles to reduce further the cost of Nano fluid based solar collector and to meet quickly with the market needs.
3- More efforts are needed to study the consistency of using Nano fluids in heat pipe from both environmental and economic point of view.
4- Nanoparticles must be dispersed uniformly in the base fluid to increase the efficiency of the heat pipe.
5-The results of the reviewed papers indicated that the overall performance of heat pipe is a function of Nano fluid properties and the other properties of system.
6. For the comparison of heat transfer coefficient and maximum heat flux using three water based Nano-fluids, it is found that the heat transfer characteristic's using three nano fluids enhance greatly compared with that of deionized water. The htc of evaporator using 20nm cu Nano fluids is 3-4% higher than that of 50nm cu Nano fluid.
7. At lower particle concentrations, the conductivity ratio showed enhancements of approximately 5.3% until 15.5%. it was observed that the temperature distribution and the heat pipe thermal resistance varied with the particle volume fraction and the size of the ZnO nanoparticle.

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