ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (135-139), Month: April 2015 – September 2015, Available at: www.paperpublications.org

Experimentation of Heat Pipe Used In Nano-Fluids

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Abstract: **Heat pipe are high-efficient heat transfer devices and have been widely applied in various thermal systems. Since heat pipe utilize the phase change of the working fluid to transport the heat, the selection of working fluid is of essential importance to promote the thermal performance of heat pipe. Owing to the heat transfer enhancement effect of nanofluid in the single phase and phase change heat transfer, some researchers have applied various nanofluids in heat pipe as the working fluids to enhance their heat transfer performance.**

Keywords: **Heat pipe, Heat transfer, Nano fluid, Heat Exchanger, Thermal system.**

1. INTRODUCTION

Heat exchangers are used in different processes ranging from conversion, utilization & recovery of thermal energy in various industrial, commercial & domestic applications. Some common examples include steam generation & condensation in power & cogeneration plants; sensible heating & cooling in thermal processing of chemical, pharmaceutical & agricultural products; fluid heating in manufacturing & waste heat recovery etc. Increase in Heat exchanger's performance can lead to more economical design of heat exchanger which can help to make energy, material & cost savings related to a heat exchange process.

The need to increase the thermal performance of heat exchangers, thereby effecting energy, material & cost savings have led to development & use of many techniques termed as Heat transfer Augmentation. These techniques are also referred as Heat transfer Enhancement or Intensification. Augmentation techniques increase convective heat transfer by reducing the thermal resistance in a heat exchanger.

Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop. So, while designing a heat exchanger using any of these techniques, analysis of heat transfer rate & pressure drop has to be done. Apart from this, issues like long term performance & detailed economic analysis of heat exchanger has to be studied. To achieve high heat transfer rate in an existing or new heat exchanger while taking care of the increased pumping power, several techniques have been proposed in recent years and are discussed in the following sections.

2. A NEW HEAT TRANSFER ENHANCEMENT APPROACH WITH NANOFLUID

There is a great need for more efficient heat transfer fluids in many industries, from transportation to energy supply to electronics. The coolants, lubricants, oils, and other heat transfer fluids used in today's conventional thermal systems (including radiators, engines, and HVAC equipment's) have inherently poor heat transfer properties, and conventional working fluids that contain millimetre- or micrometre-sized particles do not work with the newly emerging "miniaturized" technologies because they can clog in micro channels.

By applying nanotechnology to thermal engineering, researchers has created nanofluids to solve these problems. These nanofluids have an unprecedented combination of the two features most highly desired for thermal system applications: extreme stability and ultra-high thermal conductivity. It has long been recognized that suspensions of solid particles in liquids have great potential to increase heat transfer rate of fluids. The key idea is to exploit the very high thermal conductivities of solid particles, which can be hundreds or even thousands of times greater than those of conventional heat-transfer fluids such as water and ethylene glycol. Although such suspensions do indeed display the desired increase in thermal conductivity, they suffer from stability problems. In particular, the particles tend to quickly settle out of suspension and thereby cause severe clogging, particularly in mini and micro channels. A novel approach to engineering fluids with better heat-transfer properties, based on the rapidly emerging field of nanotechnology, has recently been proposed. In particular, it was demonstrated that solid nanoparticles colloids (i. e. colloids in which the grains have dimensions of 10-40 nm) are extremely stable and exhibit no significant settling under static conditions, even after weeks or months. Furthermore, the enhancement of thermal-transport properties of such "nanofluids" was even greater than that of suspensions of coarse-grained materials.

3. NEED OF WORK

A heat pipe is an excellent heat conductor, one end of a heat pipe is the evaporation section, and the other end is the condensation section. When the evaporation section is heated, the liquid in the heat pipe evaporates rapidly. This vapour releases its heat at the condensation section, which has a small vapour pressure difference, and condenses back into liquid. The condensed liquid in the condensation section then flows back to the evaporation section along the inner wall of the heat pipe and undergoes endothermic evaporation in the evaporation section. The heat transfer of a heat pipe uses a working fluid that changes phases in a continuous endothermic and exothermic cycle, giving the heat pipe excellent heat transfer performance. Many researchers have used finned tube, threaded tubes, sintered tubes, and grooved tubes to increase the contact area between the heat pipe and the internal working fluid, thus improving the heat pipe thermal performance. Thus, replacing the traditional working fluid with a working fluid with a high heat transfer performance is worth considering.

4. CONCEPT OF HEAT PIPE

Heat pipes have been utilized in heat transfer related applications for many years. Depending on their application area, they can operate over a wide range of temperatures with a high heat removal capability. Heat pipes have been found to be useful in a number of technologies such as electronic cooling, spacecraft thermal control, transportation systems, automotive industry, permafrost stabilization, bio- related applications, solar systems and manufacturing. Heat pipes and their applications in thermal management have been studied for decades. They constitute an efficient, compact tool to dissipate substantial amount of heat.

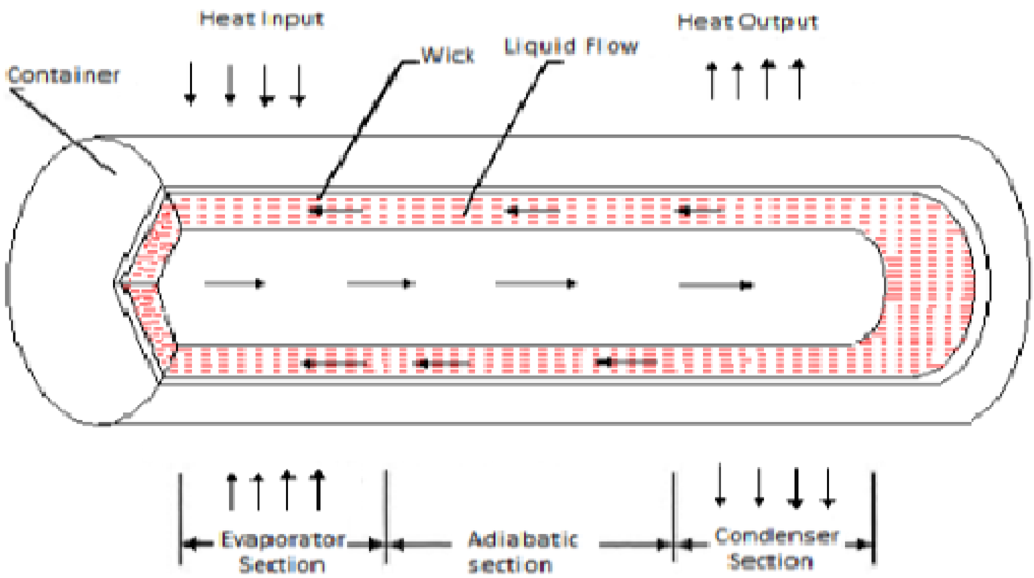

Fig.: - Concept of project

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5. EXPERIMENTAL SETUP

This apparatus consists of a screen mesh wick straight heat pipe with one side having evaporator and other having condenser. The heat input is made of copper material. The evaporator section is heated by an electrical heater surrounding at its circumferences. The condenser section is cooled by an cooling water circulating in a constant-temperature thermal bath. The cooling water is supplied with the help of centrifugal pump. Also the flow meter is attached to measure the flow of cooling water.

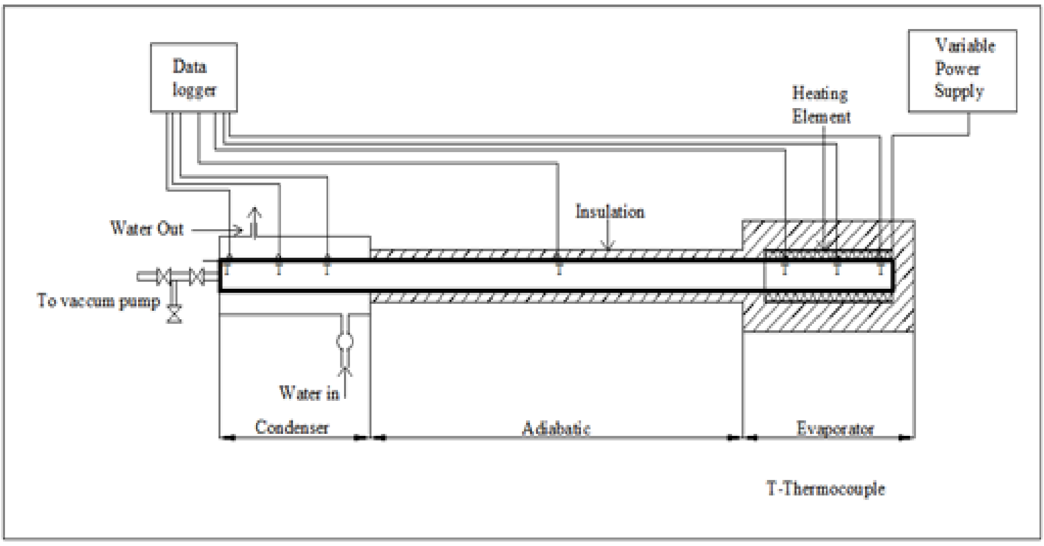

Fig.: - Schematic view of heat pipe

Fig.: - Photographic view of Experimental set-up

The temperature and flow rate of the cooling water were fixed at constant values for keeping steady cooling condition in the condenser section for varying heat fluxes. The insulation is provided on the adiabatic section to minimize the convective losses the heat pipe is placed between heater and coolant with the help of support. The thermocouples are attached at different interval to check the temperature of heat pipe. K-type of thermocouples are used to measure temperature at various sections.

6. TEST METHODOLOGY

1. The heat pipe body is made up of copper, with a length of 600 mm, outside and inside diameter of 20mm and 17.6mm respectively.
2. The heat pipe is charged with 40ml of working fluid, which approximately corresponds to the amount required to fill the evaporator. The distance between the evaporator and the condenser is normally called as the adiabatic section with a length of 300mm.
3. The wall temperature distribution of the heat pipe in adiabatic zone is measured using four thermocouples.
4. The total heat pipe is completely insulated with the glass wool material. The amount of heat loss from the heat pipe is negligible.
5. The electrical power input is applied at the evaporator section using cylindrical electric heater attached to it with proper electrical insulation and the heater is energized with 230V AC supply and measured using a voltmeter and ammeter connected in parallel and series connection respectively.
6. The evaporator and condenser have a length of 150mm in order to measure the average temperature of the evaporator, three thermocouple are distributed along the length of evaporator.
7. Water jacket has been used at the condenser end to remove the heat from condenser section of heat pipe.
8. The heat pipe has the ability to transfer the heat through the internal structure. As a result, a sudden rise in wall temperature occurs which could damage the heat pipe if the heat pipe is not released at the condenser properly. Therefore, the cooling water is circulated first through the condenser jacket, before the heat pipe is supplied to the evaporator.
9. The condenser section of the heat pipe is cooled using water flow through a jacket with two liter volume. The water flow rate is measured using a rotameter on the inlet line to the jacket, the flow rate is kept constant at the 4.5lpm, to measure the average temperature of the condenser, three equally spaced thermocouples distributed along the length of condenser.
10. The inlet and outlet temperature of the cooling water are measured using thermocouples.
11. The charging system is provided on the heat pipe for charging different working fluids.
12. The power input to the heat pipe is gradually raised to the desired levels. The surface temperatures at different locations along the adiabatic section of the heat pipe are measured at regular time interval until the heat pipe reaches the steady state condition. Simultaneously the evaporator wall temperature, condenser wall temperature, water inlet and outlet temperature in the condenser zone are measured.
13. Once the steady state is reached, the input power is turned off and cooling water is allowed to flow through the condenser to cool the heat pipe and to make it ready for further experimental purpose.
14. The steady state condition is defined as a state in which the variation of temperature is within 1^0C for 10 min. Then the power is increased to the next level and the heat pipe is tested for its performance.
15. Experimental procedure is repeated for different heat input (30, 40, 50,60W) and different inclination of pipe (0^0,15^0,30^0,45^0,60^0,75^0,90^0)to the horizontal position and observation are recorded. The output heat transfer rate from the condenser section is computed by applying an energy balance to the condenser flow.

7. CONCLUSION

1. Thermal resistance of heat pipe decreases with increase in concentration of nanofluid in heat pipe and increase inclination angle compared with distilled water as working fluid.
2. Heat pipe shows better performance in the range of angle of inclination between 30-60. Maximum performance observed at 45^0 angle of inclination.
3. Better performance is observed for Al_2O_3 nanofluid with 2wt% concentration of independent nanofluid.
4. With increase in inclination angle of heat pipe the thermal resistance reduces. For 30W heat input,2wt% concentration of Al_2O_3 and 45^0 angle of inclination, the resistance is reduced by an amount of 16.68% compared with 0 inclination for same working fluid.
5. With increase in heat input for nanofluid, the thermal resistance of heat pipe reduces. For 60W heat input, 1.5wt% concentration of Al_2O_3 and 45^0 angle of inclination, the thermal resistance is reduced by an amount of 46.62% compared with same working fluid with 30W heat input. From the above experimentation it is concluded that the heat pipe using nanofluid as working fluid can give the permission results compared with water as working fluid.

8. FUTURE SCOPE

In recent papers single nanofluids used as working fluid in different type of heat pipes. In future aspect two nanofluids or more nanofluids will be using as a working media in different heat pipes and determine the effect of thermal performance of mixture two or more nanofluids i.e. hybrid nanofluids used on different concentration and different inclination angles.

1. Investigating the optimum size of nanoparticle that will give better heat transfer performance.
2. Investigation of new nanomaterial’s that will give higher heat transfer performance in heat pipe.
3. Investigate the optimum maximum percentage of nanomaterial in hybrid nanofluid that will give better heat transfer performance.
4. To find out the optimum flow rate of coolant that will give better heat transfer in condenser section.
5. Investigate the optimum size of heat pipe that will give better performance.

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