Heat transfer enhancement in thermosyphon with nanofluid

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Abstract--Heat transfer enhancement in a two phase closed thermosyphon was studied. CuO nanofluid and deionized water as a working medium was investigated. The experiment was carried out at different heat input of 10W and 16W. To see the effect of inclination angle, thermosyphon was varied at different inclination angle of 30°, 45°, 60° and 90°. The average size of the nanoparticles were around 50 nm in size.

Keywords: CuO nanoparticles, Ethylene Glycol, Thermosyphon.

1. Introduction

Heat transfer through natural convection is an important phenomenon in electronic cooling, heat exchanger and heat recovery systems. Enhance heat transfer is highly essential in industry as well as in energy saving perspectives. A thermosyphon is a heat transfer device which is used for transmitting heat from evaporator section to the condenser section with relatively smaller heat input and pressure drop. It is a wickless heat pipe. It consists of three parts. They are evaporator, adiabatic and condenser section. The evaporator section must be placed below the condenser section to facilitate the flow of condensate back to the evaporator section [1-5].

The TPCT has a simple structure and low thermal resistance, higher efficiency and low manufacturing costs. Because of these advantages it finds application in many fields such as electronic component, solar heating systems, heat recovery systems [6–9]. A lot of research is being carried out to improve the efficiency of the heat pipe. Nanofluid which is a mixture of nanoparticles and base fluid is a potent liquid used for transmitting heat. They have higher thermal properties compared to that of water.

From the survey of literature it can be found that a lot of study has been made to increase the thermal performance of the thermosyphon using different nano-refrigerants, ethanol, methanol, D.I water. But a few research has been carried out with CuO nanofluid with free convection as a working medium in thermosyphon.

2. Materials and Methods

A. Nanofluid Preparation

CuO nanoparticle were purchased from Srlchem(Mumbai). The average diameter of the nanoparticle were around 40-50nm in size. SEM(Scanning Electron Microscope)image conforms it in fig. 1. For the preparation of CuO nanofluid, two step method was used. Deionized water(D.I) was used as a base fluid. To prepare the nanofluid, required concentration of CuO nanoparticles were taken along with ethylene glycol as a surfactant and mixed in D.I water. After that sonication is done for five hours in Ultrasonic bath to disperse the nanoparticles in the base fluid. The two step method was followed and extensively used because it is easy to prepare the nanofluid and works well for oxides nanoparticles. Concentration of 0.002 wt.% was used for the study.
B. Experimental setup

For carrying out the experiment, thermosyphon was made of copper material. The total length of the pipe is 205mm and the outer diameter is 6mm. It has three sections mainly evaporator, adiabatic and the condenser section. Glass wool fiber is used to make the section adiabatic. The temperature distribution at the wall of the thermosyphon are measured with K- type of thermocouple. Thermocouples are attached to the body of the thermosyphon to measure the wall temperature at different location of the copper pipe. All these thermocouple were connected to the temperature indicator.

In the evaporator section, a heater is fixed to apply constant heat input. The heat input was measured by using wattmeter. The power is varied with the help of an autotransformer and the condensing section was placed at a higher level to allow the flow of condensate back to the evaporator section.

C. Working Procedure

The study was made to enhance the heat transfer in the thermosyphon. The power button was turned on and the heat input incremented from 10W to 16W. When steady state was attained after one hour, the temperature distribution was measured with the help of the temperature indicator.

3. Results and Discussions

A. Wall temperature of the thermosyphon

Fig. 2 a-d. shows the wall temperature distribution of the thermosyphon at different concentration, heat input and inclination angle of the thermosyphon. It is observed from the figure that for every heat input and inclination angle, wall temperature of 0.002 wt.% of CuO nanofluid is less compared to that of D.I water. This may be due to the enhanced thermal properties of the nanofluid. Moreover, as we go from the evaporator section to the condenser section, there is a decreasing temperature gradient. The inclination angle also plays a major role in heat transfer. For an inclination angle of 60º, wall temperature of thermosyphon is lesser compared to that of the other inclination angles of 30º, 45º and 90º. It may be due to the uniform condensate flow from the evaporator section to the condenser section of the thermosyphon.
B. Variations of Thermal Resistance with various Heat inputs

The thermal resistance of the thermosyphon was found to decrease with the increase in heat inputs. The efficiency of the thermosyphon increases with increasing the heat input at the evaporator section. At higher heat input, the amount of heat transfer was higher than the lower heat input to the working medium in the thermosyphon. This is mainly due to the fact that at a higher heat input, sufficient amount of vapour pressure is developed inside the thermosyphon which helps in transmitting the heat from the evaporator section to the condenser section at a faster rate. This leads to lower thermal resistance in thermosyphon at a lower heat input.

It can also be noticed from the fig. 3a, that at a higher heat input of 16W, thermal resistance is less compared to that of 10W heat input for all the inclination angle of the thermosyphon. Moreover, lowest thermal resistance is observed at an inclination angle of 60° compared to the other inclination angle. This is mainly due to development of higher pressure drop in the evaporator section which facilitates better heat transportation, thus reducing the thermal resistance.
4. Conclusion
An experimental investigation was performed to analyse the effect of CuO nanofluid on the thermal performance of a thermosyphon. Results showed that CuO nanofluid enhances the thermal performance of the thermosyphon significantly. With the application of CuO nanofluid, there is a decrease in the wall temperature of the thermosyphon. Thermal resistance decreases at higher heat input. Thermosyphon performs better at 60° inclination.

5. References
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