

## Effect of Geometric Changes in an Adiabatic Section of Thermosiphon Using $\text{TiO}_2$ & $\text{Al}_2\text{O}_3$ Nanofluid

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### Abstract

**Objectives:** The thermosiphon is a device that transfers heat from a source to the environment. Electric and electronic supplies generate a greater amount of heat, so it's critical to transfer the heat efficiently. So we used  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  nanofluid as a working fluid and made geometrical changes in the adiabatic section to improve the heat transfer efficiency.

**Methods:** We tested thermosiphons with  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  as working fluids in the heat input range of 50–300W at different inclination angles ( $0^\circ$ ,  $45^\circ$  and  $90^\circ$ ), investigations are conducted. CFD flow analysis of thermosiphon such as fluid to steam phases all works carried on ANSYS FLUENT 18.1.

**Findings:** The heat transfer coefficient of thermosiphon at different inclination points ( $0^\circ$ ,  $45^\circ$  and  $90^\circ$ ) are find through by calculating heat transfer parameters. We find the heat transfer rate, pressure drop, mass stream rate, water.volume.fraction, stream.volume.fraction by using ANSYS FLUENT 18.1.

**Novelty:** We increase the heat transfer coefficient of the thermosiphon by using  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  as a working fluid and made geometrical changes in the adiabatic section of the thermosiphon to increase the flow rate of working fluid. This thermosiphon is suitable for electronic cooling applications due to its shift in adiabatic portion, which increases heat transfer efficiency and reduces weight.

**Keywords:** Thermosiphons, Geometrical change, Nanofluid, Heat transfer, ANSYS CFD.

### 1. Introduction

Two-phase closed thermosyphon as a gravity-assisted heat pipe is an efficient heat transfer device in which heat transmits by evaporation and condensation of a working fluid

<sup>[1,2]</sup>. Thermosiphons are made of copper alloy, K type thermocouples are used to estimate temperature. Nanofluids are suspensions of nano-sized solid particles in a base fluid which can be used as heat transfer media in the thermosiphon<sup>[2,3]</sup>. The thermosiphon is mostly used in electronic cooling equipment. Several studies have been conducted to better understand the cooling logic as well as to enhance the heat transfer of thermosiphons<sup>[4]</sup>. Many studies have been conducted based on its heat inputs and working fluids. The thermosiphons use working fluids such as water, methanol, ethanol, lithium, bismuth, sodium, cesium and some of the nano fluids <sup>[5]</sup>. we are using TiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> nanofluids as working fluids in thermosiphons<sup>[6]</sup>. We tested thermosiphons with TiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> as working fluids in the heat input range of 50–300W at different inclination angles (0°, 45° and 90°)<sup>[7]</sup>. The readings are used to calculate the heat transfer coefficient of two phase closed thermosiphon<sup>[7,8]</sup>. Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical analysis and algorithm to solve and analyze problems that involve fluid flows<sup>[9]</sup>. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by the boundary with high-speed supercomputers better solutions can be achieved<sup>[10]</sup>. Geometrical changes are made in adiabatic section of thermosiphon to increase the flow rate of working fluid in thermosiphon<sup>[11,12]</sup>. CFD analysis is to find the heat transfer rate, pressure drop, mass stream rate, water.volume.fraction, stream.volume.fraction by using ANSYS FLUENT 18.1.

## 2. Materials and Methods

The equipments used in the two-phase closed thermosiphon are Resistance warmer, voltmeter, current meter, chilling unit, transformer, and information are stored with the help of the PC. The external diameter of thermosiphon is 25 mm, and the evaporator and condenser lengths were 300 mm the adiabatic segment was around 1000 mm in length. The temperature distribution of thermosiphon is monitored by using T type thermocouples. The thermocouples are linked to a computer for data verification and storage. The filling proportion was determined to be 30% volume, and water flow rate to the condenser was also fixed as 590 ml/m. The rate of water flow is obtained from trial runs at which minimum temperature difference is found. TiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> nanoparticles with a diameter of 30-40nm are mixed in DI water at a 49:1 ratio with a concentration of 1g/l.

### 3. Estimated Heat Transfer Parameters

The heat flux, heat transfer coefficient and thermal resistance are calculated using the following relations.

$$h_e = \frac{q_e}{T_e} \quad (1)$$

$$h_c = \frac{q_c}{T_c} \quad (2)$$

Where h, q and T indicates the warmth move coefficient, heat motion and temperature for evaporator and condenser. The  $q_e$  and  $q_c$  are determined utilizing conditions that are

$$q_e = \frac{\dot{Q}}{2\pi r l_e} \quad (3)$$

$$q_c = \frac{\dot{Q}}{2\pi r l_c} \quad (4)$$

Where l is the length of evaporator and condenser and Q is heat move in two phases closed thermosiphon. Additionally, the all-out warm obstruction is gotten utilizing condition.

$$R_t = \frac{T_e - T_c}{\dot{Q}} \quad (5)$$

### 4. Results and Discussion

#### 4.1 The effect of temperature, heat flux & heat transfer co-efficient on geometrically changed thermosiphon

We made a geometric change in adiabatic section of two-phase closed thermosiphon, TiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> nanofluids as a working fluid. Experiments are carried out at different inclination angles (0°, 45° and 90°) at various heat input range of 50–300W. Heat transfer co-efficient & heat flux are find through by calculating heat transfer parameters. After calculating heat transfer parameters, the values are converted into graphs are shown in (figure 1-6). The graphs explain the heat transfer co-efficient & heat flux of thermosiphon at different inclination angles. When comparing these graphs heat transfer at 45° gives a great result than other two angles. The results are compared with different research papers<sup>[2]</sup>. By

using  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  nanofluids as a working fluid at  $45^\circ$  inclination angle increased the heat transfer coefficient of thermosiphon.

Fig 1- Resistance vs Temperature at 0 degree

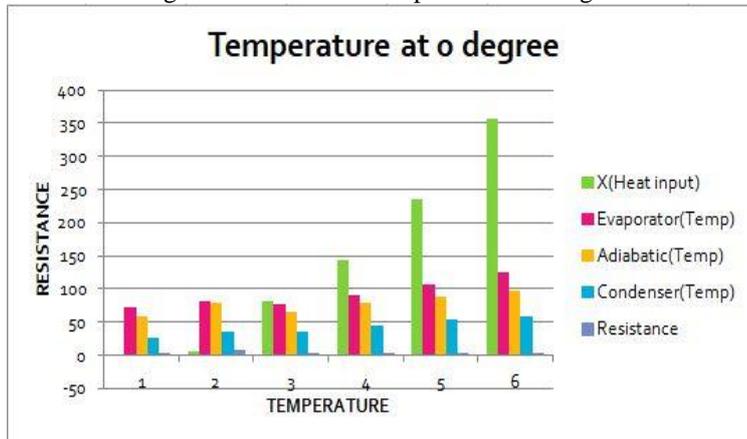


Fig 2 - Resistance vs Temperature at 45 degree

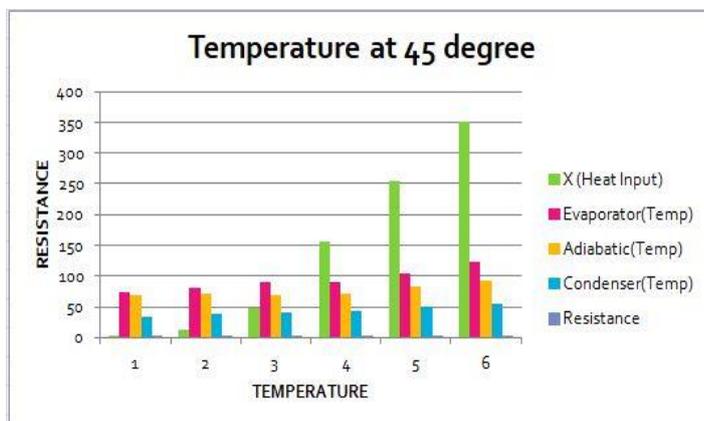


Fig 3 - Resistance vs Temperature at 90 degree

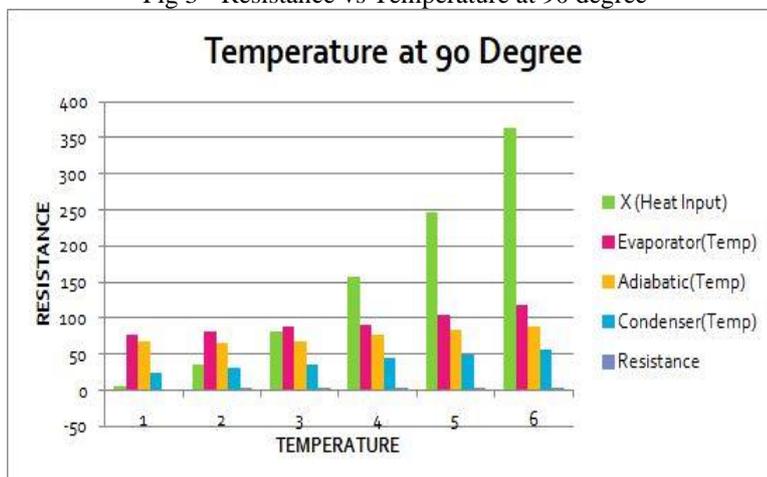


Fig 4 - Heat transfer co-efficient vs Heat flux at 0 degree

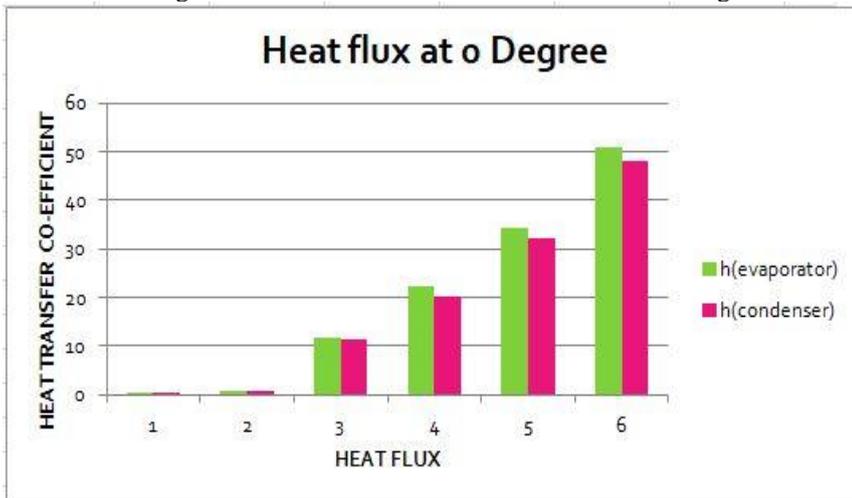


Fig 5 - Heat transfer co-efficient vs Heat flux at 45 degree

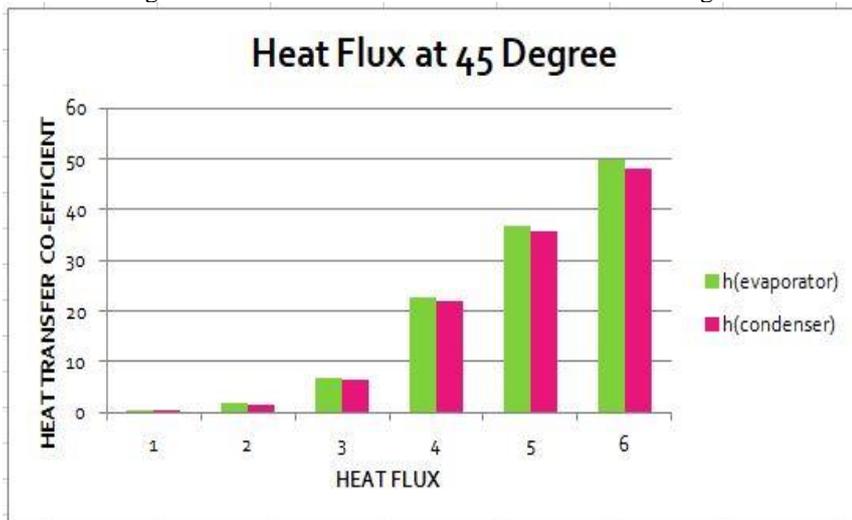
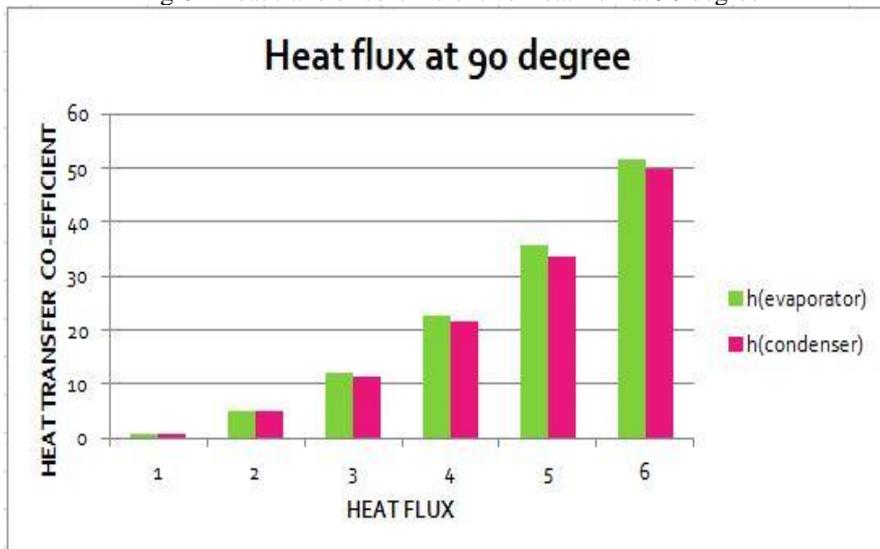


Fig 6 - Heat transfer co-efficient vs Heat flux at 90 degree



## 4.2 Estimated Computational Fluid Dynamics Analysis

CFD (Computational Fluid Dynamics) is a software program that performs numerical analysis on fluid flow, heat transfer rate. It includes a series of algorithms for modeling and simulating fluid flow, electric currents, heat, and gases. These steps are carried out to create a model in CFD modeling, meshing, and then analysis. The geometric changed thermosiphon is created and analysis is carried out through ANSYS FLUENT 18.1. The heat transfer coefficient, mass flow rate, pressure drop, and heat transfer rate with water vapour are analyzed. The analysis images represent the water volume fraction of geometric change thermosiphon are shown in (figure 8&9). The analyzed images showed that flow rate is increased in thermosiphon by using  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  nanofluids as a working fluid. when compared to other nanofluids its flow rate is increased.

Fig 7 - SEM image of condenser section

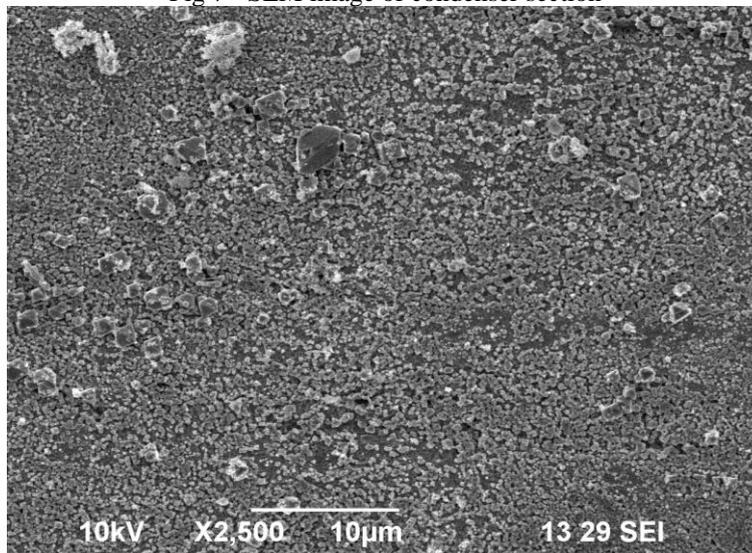


Fig 8 - Water volume fraction contour of geometry changed thermosiphon

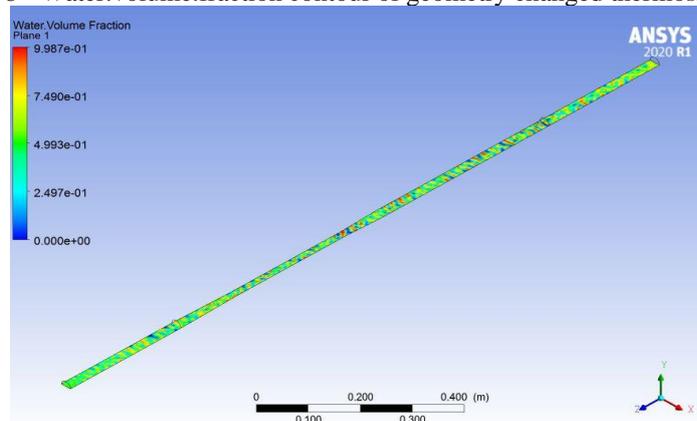
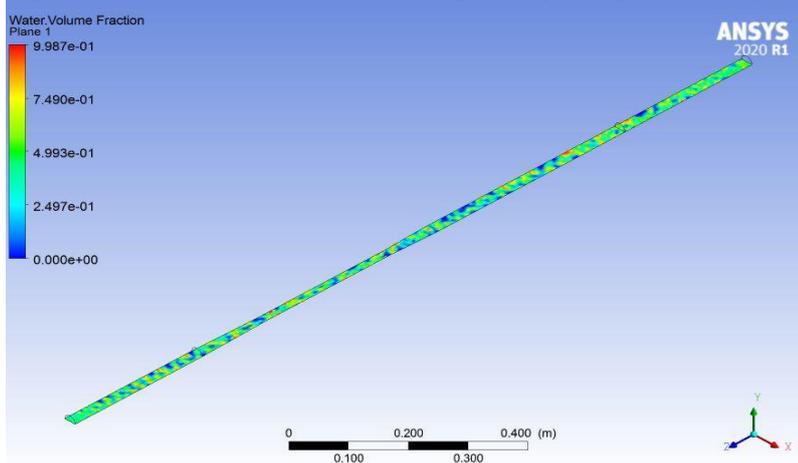


Fig 9 - Water.volume.fraction contour of geometry changed thermosiphon



## 5. Conclusion

The effect of geometric changes in an adiabatic section of a two-phase closed thermosiphon is demonstrated in this study. As a working fluid,  $\text{TiO}_2$  &  $\text{Al}_2\text{O}_3$  and nanofluids were used. In this experiment, a two-phase closed thermosiphon was filled with nanofluids as a working liquid at a 30% filling proportion. Thermosiphons were measured at various inclination points ( $0^\circ$ ,  $45^\circ$ , and  $90^\circ$ ) in the 50–300 W heat input range. The evaporator and condenser sections heat transfer coefficients are increased due to geometric changes in the thermosiphon, as seen in the CFD analysis images and also we attached the SEM image of the geometric changed thermosiphon shown in [Figure 7]. This thermosiphon is suitable for electronic cooling applications due to its shift in adiabatic portion, which increases heat transfer efficiency and reduces weight.

## 6. Limitations and Future scope

CPUs can be used for large tasks such as rendering images, editing, gaming, and so on. The scope to develop the processing speed of the computer by cooling it in a perfect manner by using the thermosiphon as a cooling equipment.

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