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Experimental Studies on Geometrically Changed Thermosiphons Using Al_2O_3 Nanofluid

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Abstract
Objectives: *To understand the two-phase closed thermosiphons (TPCT) which is being used nowadays to reduce heat by using thermosiphon.*
Methods: *The experiment is carried out with different inclination angles and by calculating the heat transfer parameters (mention them) 0°,45°,90° with the heat input of 50-250w and compare with previous results.*
Findings: *The TPCT mainly has many advantages, having the capacity of transferring a high amount of heat in a small size. Nanofluid play an important role in the aluminum oxide (Al2O3) Nanofluid is used because of high thermal conductivity and low thermal resistance, Due to the presence of this Nanofluid, the heat transfer rate in the evaporator section gets decreased and at the time of applying the highest heat flux the thermal resistance tents to be low.*
Novelty: *Aluminum oxide (Al2O3) Nanofluid was tested in the various setting angles 0°, 45°,90°. Among these 45° have shown better performance in all the properties such as low temperature and high heat transfer rate and high thermal conductivity. So the 45° have shown better performance compared to the other two setting angles.*
Keywords: Thermosiphons, Al_2O_3 Nano Fluid.

1. Introduction

The two-phase closed thermosiphons which have many advantages, having a capacity of transferring high amount of heat in a small size. It also has various merits of high anti-gravity capacity and heat transfer, used in cooling the electronic devices and CPU [1]. It transfers heat by means of the latent heat of working fluid in the tube. This type of process cannot require external force for heat transferring purpose and the efficiency was also high [2]. Many works are being carried-out improving the heat transfer rate by varying the many parameters such as filling ratio, geometry, and the heat input given and also by changing the fabrication materials [3]. Here the fabrication is done by means of

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copper and the working fluid used here is the distilled water [4] it was prepared in the ratio of 98% distilled water and 2% of Al_2O_3 and the filling ratio is 30% and the flow rate is 590 ml/min [5]. And TPCT are currently have been applied in many industries such as energy engineering, metallurgical engineering and chemical engineering for the purpose of removing heat the property of the Nanofluid play an important role in the improvement of the heat transfer in TPCT [6]. The aluminum oxide Al_2O_3 Nanofluid is used because of high thermal conductivity and low thermal resistance, Due to the presence of this Nanofluid the heat transfer rate in the evaporator section gets decreased and at time of applying the highest heat flux the thermal resistance tents to be low [7]. Nanofluids are also used as a thermal medium for the purpose of improving the heat transfer, many researches are been going in the application of nanofluids in the thermosiphons. The average of the temperature in the evaporator section found to be low by using the Al_2O_3 Nanofluid [8]. The performance of the thermosiphons by using the Nanofluid have been studied in the different angles such has 0°, 45°,90°, and conclude that which angle among these three shows better performance [9]. In most of the condition the cooling of the Nanofluid is done by means of the forced convection by taking thermal conductivity and thermal resistance in to account, but here we are using the natural convection for the Nanofluid cooling [10].

2. Experimental Setup

2.1 Preparation of Nanofluid

The Nanofluid is prepared by using the Al_2O_3 2% and the distilled water 98%, Distilled act has the base for the fluid and they are mixed in the 49:1 for the preparation of the fluid. After the preparation sample completed it look like milky. The process of preparing the Nanofluid is given below image Fig (1). First the weighing of distilled water is done and then weighing of Al_2O_3 is done and then mixing of the two is done a then at last the ultrasonication is done for SEM image preparation.

Fig 1 - preparation of Nanofluid

2.2 Morphology of Aluminum oxide Al_2O_3 Nanoparticle (Scanning electron microscope)

Scanning electron image (SEM) image of aluminum oxide (Al2O3) nanofluid is prepared, it is found that the particle is smaller in size and uniformly distributed.

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Fig (1),Fig (2),Fig (3),Fig (4), Fig (5) are the sem images of specimen A1

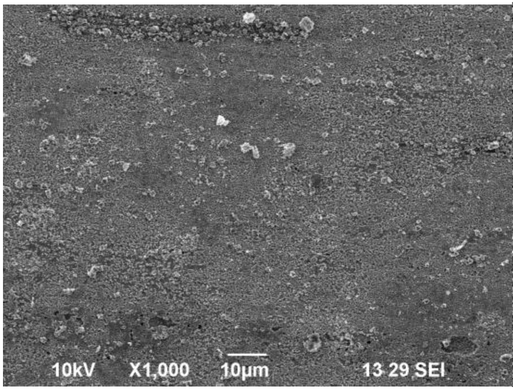

Fig (2).

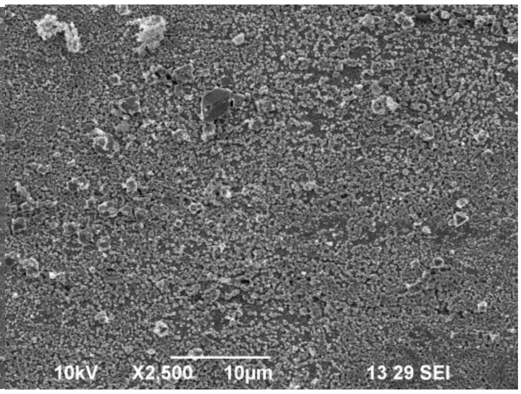

Fig (3).

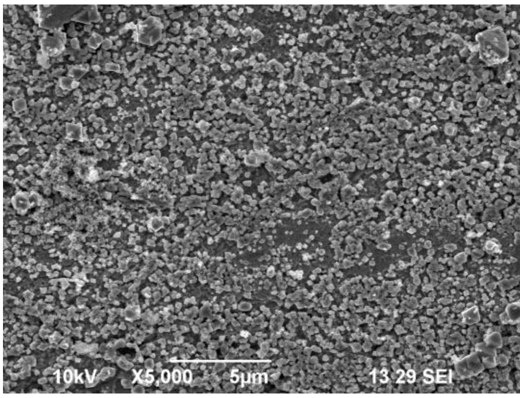

Fig (4).

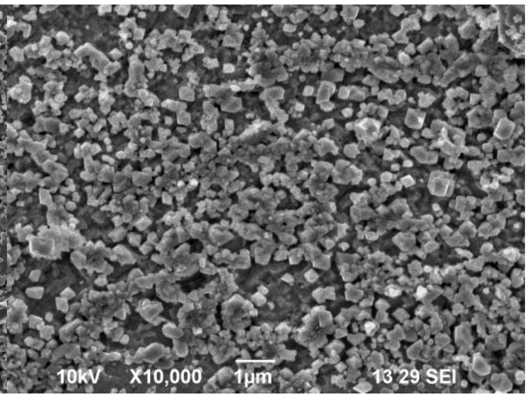

Fig (5).

Fig (6), Fig (7), Fig (8), Fig (9) are the SEM images of specimen A2

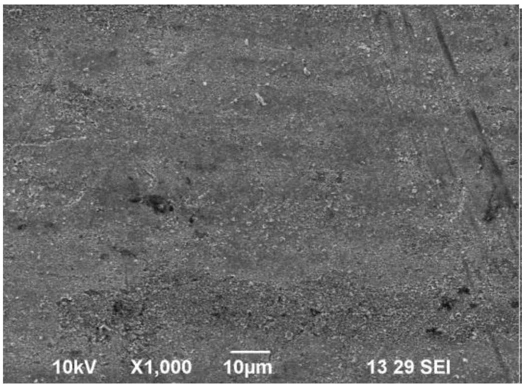

Fig (6).

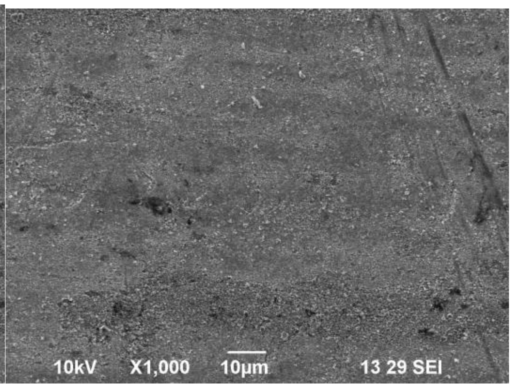

Fig (7)

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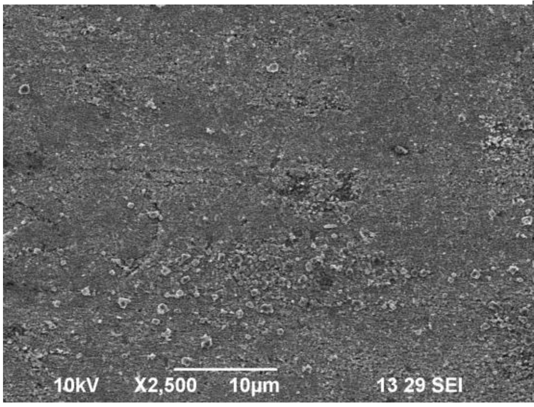


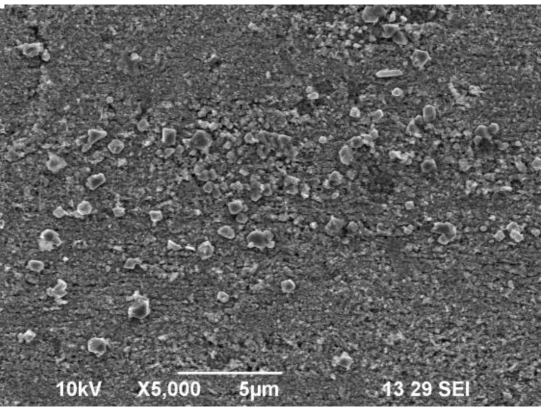
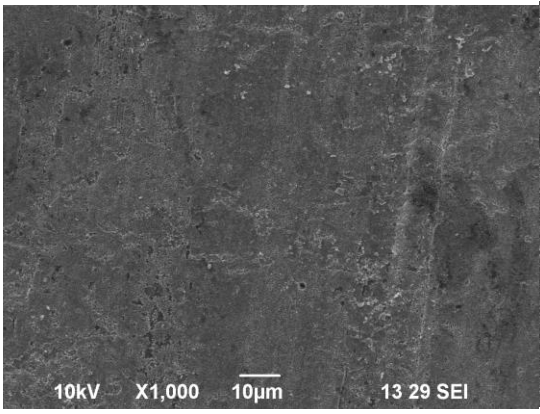


Fig (8). Fig (9).

Fig (10), Fig (11), Fig (12), Fig (13) are the SEM images of specimen C



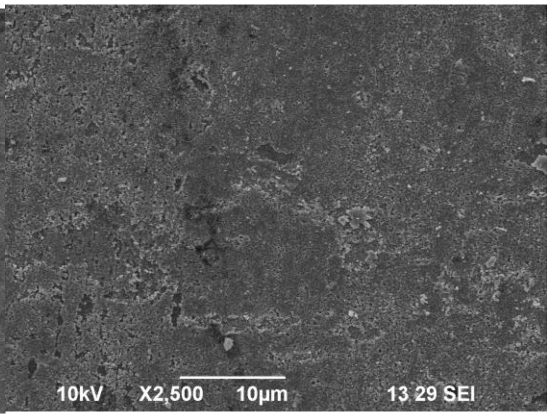
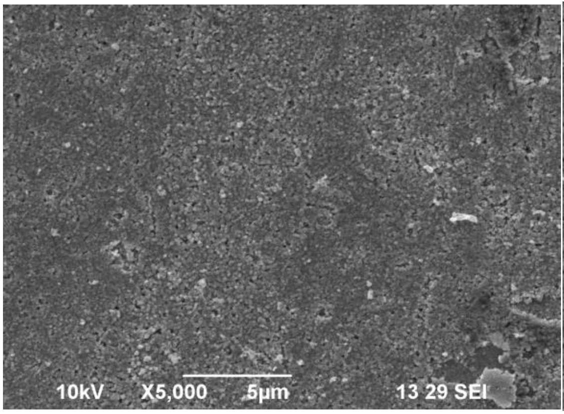


Fig (10). Fig (11).



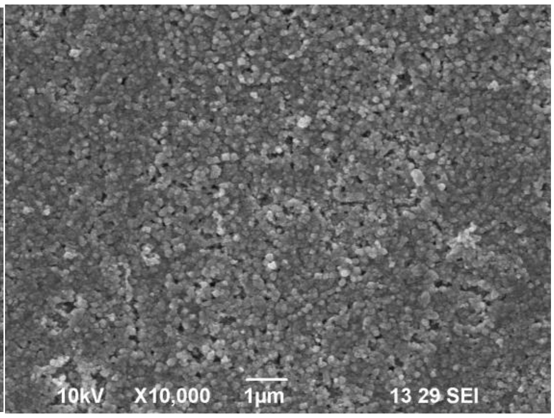


Fig (12). Fig (13).

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Fig (14), Fig (15), Fig (16), Fig (17) are the SEM images of specimen E

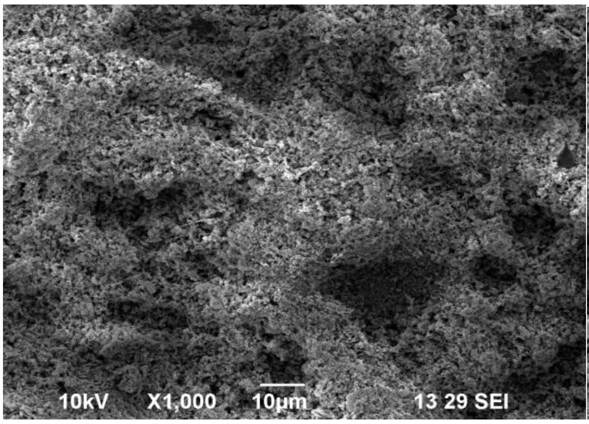

Fig (14).

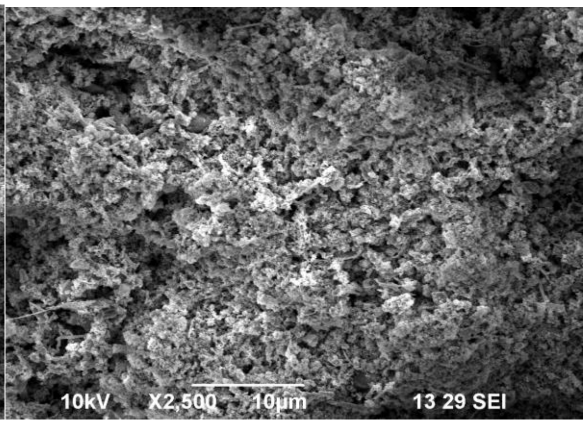

Fig (15).

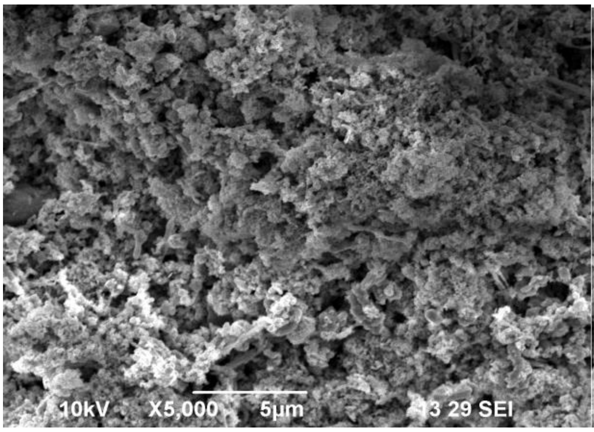

Fig (16).

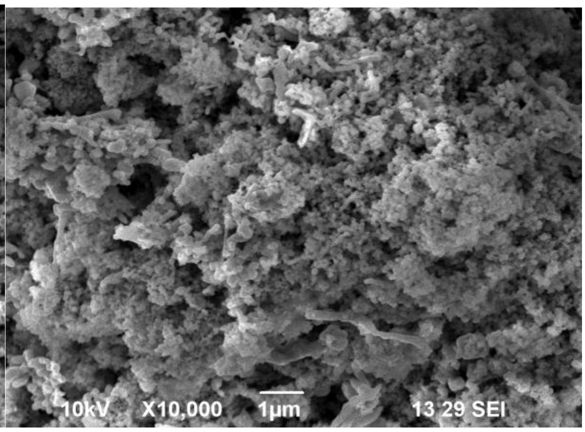

Fig (17).

2.3 Experimental procedure and setup

The diagram of the experimental setup of the thermosiphon is shown in the Fig (18). For the purpose of evaluating the Nanofluid and the thermal performance, an experimental setup of TPCT has been designed. The length of the three section such as adiabatic, evaporator, condenser section is 1000, 300,300 mm respectively. The outer diameter of the tube was 25mm and its thickness was 0.8mm. The material of it was copper for the purpose of highest heat transfer capacity. Twelve K-type thermocouples were used to measure temperatures. Three of them are in evaporator and six of them are in adiabatic section and three of them are in condenser section. For calculating the average temperature in each section, the flow rate has to be maintained constant at 590ml/min.

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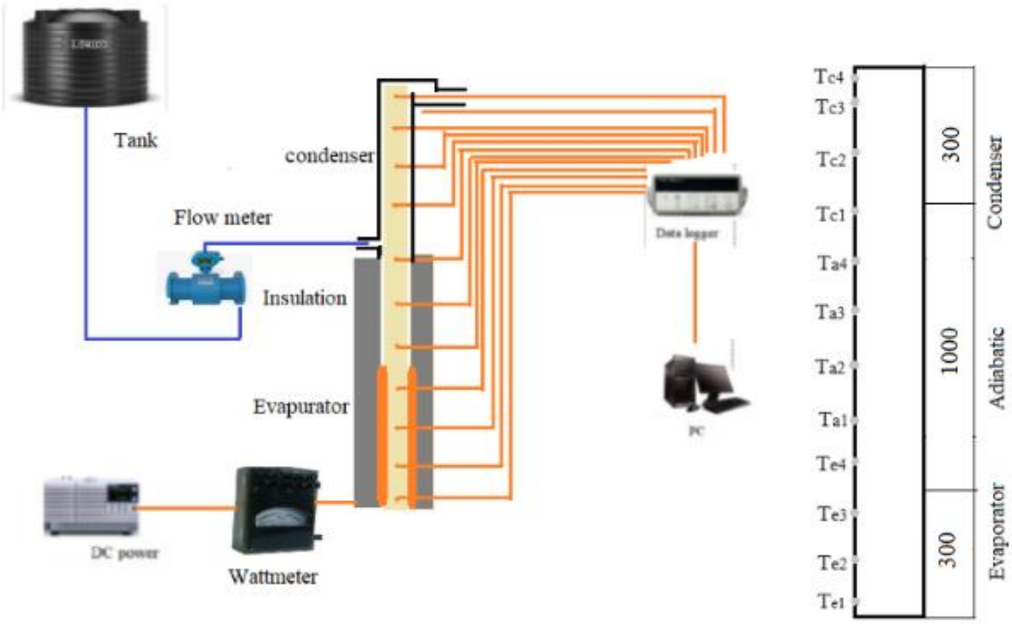
Fig 18 - Experimental set up.



The distribution of the thermocouple and the distance between them are given in the below table, and there twelve thermocouples are present in it. Three of them are present in the Evaporator, six thermocouples in Adiabatic section and three thermocouples in the condenser section. The position of them are given in the below table (1).

Table 1

TPCT zone	Evaporator	Adiabatic	Condenser
Temperature position	T1 T2 T3	T4 T5 T6 T7 T8 T9	T10 T11 T12
Initial position (mm)	0 150 300	450 600 700 900 1000 1150	1300 1450 1600

2.4 Testing conditions

The testing condition parts mainly consist of parameters such as Filling ratio, Heat input, Inclination angle, and Flow rate. They are given in the below table (2).

Table 2

S. No	Filling Ratio (%)	Heat Input(W)	Inclination angle (°)	Flow rate(ml/min)
1.	30	50-250	0	590
2.	30	50-250	45	590
3.	30	50-250	90	590

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3. Reduction

For the purpose of studying the heat transfer performance of the two-phase closed thermosiphons (TPCT), heat transfer co-efficient, heat transfer by the thermosiphons, and the thermal resistance have to be calculated.

The rate of the heat transferred by the thermosiphons is calculated by using the formula.

$$Qout = M \times C\ (Tout - Tin)$$

The heat transfer co-efficient for the evaporator and condenser section are calculated by using the formula.

Heat transfer for evaporative section.

$$he = \frac{qe}{\Delta T} = \frac{qe}{Te - Tv}$$

Heat transfer for condenser section.

$$hc = \frac{qc}{\Delta T} = \frac{qc}{Tc - Tv}$$

Were the value of $q = \frac{Q}{A}$ were $A = \pi\, dl$

The temperature of the evaporator and condenser calculated by the average value of the thermocouples.

$$Te = \frac{T1 + T2 + T3}{3}$$

$$Tv = \frac{T4 + T5 + T6 + T7 + T8 + T9}{6}$$

$$Tc = \frac{T10 + T11 + T12}{3}$$

The total thermal resistance of the two phase closed thermosiphons are calculated by using the formula.

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$$R = \frac{\Delta T}{Qout} = \frac{Te - Tc}{Qout}$$

4. Result and Discussion

In the experiment, the effect of the geometrical changes in the inclination angles of 0°,45°,90°, and the heat input of 50- 250W. The heat transfer performance of the two-phase closed thermosiphons has been studied. And find out that which among the above angles shows the efficient result.

The temperature distribution in the two-phase closed thermosiphons have been calculated, From the experiment that we have carried out we have found that the temperature is higher in 0° and 90° in the all three-section compared to the 45° inclination angle. The temperature in the evaporator at the 0° and 90° degree was measured to be 85°C and 80°C in the 45° angle it was measured to be 76°C. It was 10°C lesser than the highest value noted and this reduction is because of the angle variation in the thermosiphons, and the enhancement of the heat transfer have been found in the 45° angle.

Because of these setting angles the variation in the heat flux and the heat transfer coefficient also noted on comparing 45° with the other two degree the variation is found in the 45° degree angle the reduction of both the heat flux and the heat transfer co-efficient have been noted. They are found to be increased in 0° and 90°, In addition to that the reduction in the heat transfer rate also noted in the 90° setting angle. But in the 45° the heat transferring rate is comparatively high.

It has been found that it also impacts the thermal resistance in the two-phase closed thermosiphon, on comparing the resistance for the input that we have given and the heat transfer occurring in the evaporator and the condenser section. Is responsible for the whole heat transfer occurring in the thermosiphon, the higher amount of resistance was found in the 90° due to the maximum amount of the gravity and lower resistance was found in the 0° and 45° degree.

The relation between temperature and thermocouples at various setting angles.

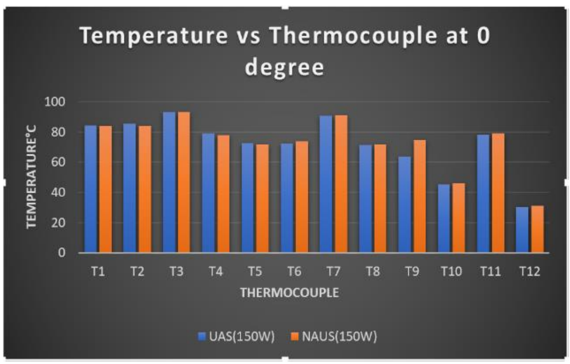

Fig 19 - Temperature vs thermocouple at 0 degree.

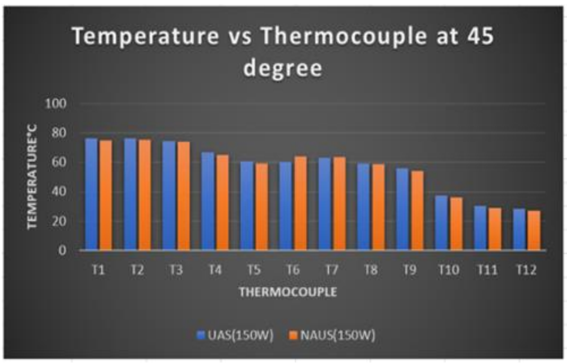

Fig 20 - Temperature vs thermocouple at 45 degree.

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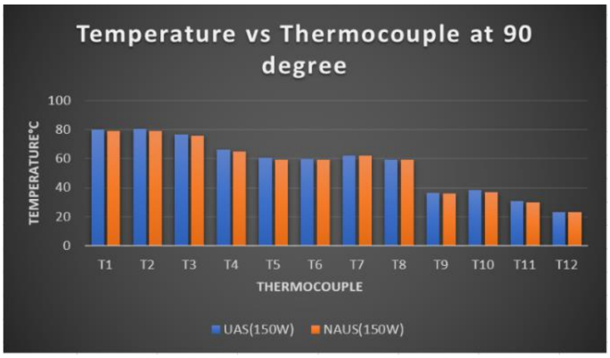
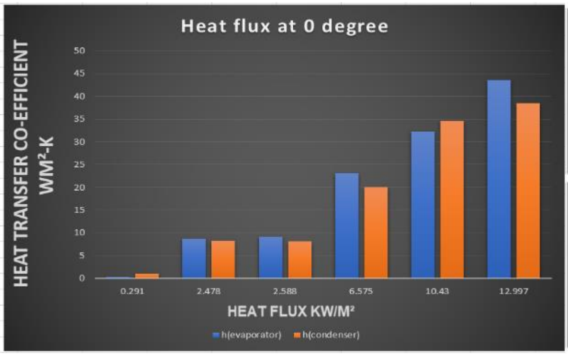


Fig 21 - Temperature vs thermocouple at

90 degree

The relation between heat transfer co-efficient and heat flux at various setting angles.



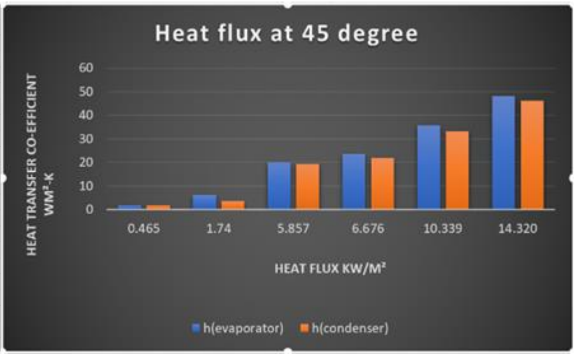


Fig 22 - Heat transfer co-efficient vs heat flux at 0-degree

Fig 23 - Heat transfer co-efficient vs heat flux at 45-degree

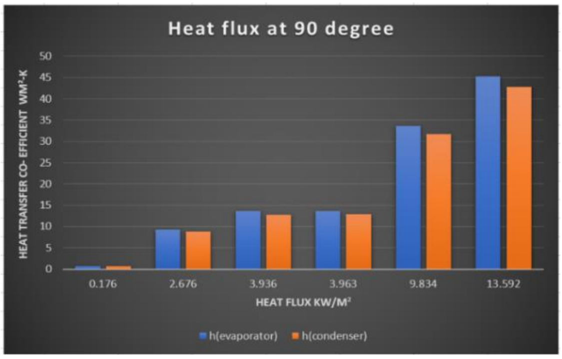


Fig 24 - Heat transfer co-efficient

vs heat flux at 90-degree

The relation between resistance and temperature at various setting angles.

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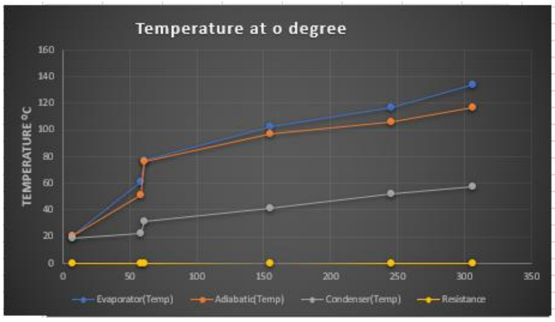

Fig 25 - Temperature vs resistance at 0-degree.

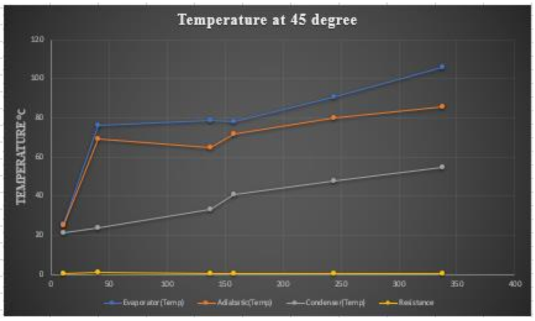

Fig 26 - Temperature vs resistance at 45-degree.

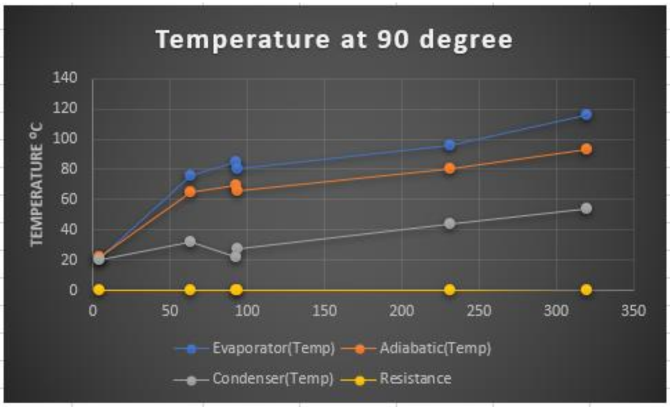

Fig 27 - Temperature vs resistance at 90-degree.

5. Conclusion

The performance of the two-phase closed thermosiphons was examined with the distilled water aluminum oxide (Al2O3) Nanofluid was tested in the various setting angles 0°, 45°, 90°. Among these 45° have shown the better performance in the all the properties such as low temperature and high heat transfer rate and high thermal conductivity. So the 45° have shown the better performance compared to the other two setting angles.

Nomenclature

ΔA- change in area (m^2)

D-Diameter(m)

q-Acceleration due to gravity (m/s^2)

h-Heat transfer co-efficient (W/m^2)

K-Thermal conductivity (W/m^2)

L-Length (mm)

T-temperature (°C)

Q-Heat Input(W)

ΔQ-Change in the heat transfer.

Q-Heat flux (W/ m^2)

Δq-Change in heat flux (W/ m^2)

R-resistance(C/W)

r-radius(mm)

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Subscripts.

c-condenser.

e-evaporator.

v-vapor.

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