Exprimental Investigation of The Copper Oscilating Heat Pipe Using Nanofluid

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Abstract- *Oscillating heat pipes are the devices used to transfer heat energy in the latent form. This study represents the experimental study of oscillating heat pipe and use of α-Fe2o3/kerosene Nano fluids. The heat rate, heat transfer coefficient and resistance of the Nano fluid were examined. Vacuum at 0.2bar is created to draw the Nano fluid Fe2o3 into the oscillating heatpipe and is removed after the filling of Nano fluid into the oscillating heat pipe. The oscillating heat pipe is modified by adjusting the angle of 45oinsted of 'U' turn at the evaporator section and an aluminium wick is placed inside the tube at the inner circumference of the copper tube. The Nano fluid at evaporator get heated up at the start of experiment and under goes phase change into vapour due to density difference the vapour tends to move upward direction in the process the vapour plug pushes the liquid plug in the copper tube but due to placing of the wick the fluid flow gets disturbed creating enhanced Thermal performance. The evaporator is heated with indirect heating and the condenser is cooled by the forced air circulation by the condenser.*

Keywords- Heat transfer coefficient, Resistance of Nano fluid, Oscillating heat pipe, Fe2o3/kerosene Nano fluid, Aluminium wick.

I. INTRODUCTION

The pulsating heat pipes, known as the oscillating heat pipes(OHPs).The oscillating heat pipes are passive heat transfer systems which date backs to 1990s. To eradicate the local localized heat fluxesAkachiet al maintained two phase heat transfer by maintaining constant cooling at condenser section when the temperature between condenser section and evaporator section the liquid and vapour plugs are formed due to density difference between vapour and liquid plugs vapour oscillates towards the condenser section and condense to liquid .Hajianet alby preparing the Ag-water Nano fluids with various size Nano particles and concentration of 50,200 and 600 ppm 300 to 500W heat input with an angle of 45o tilt angle. The thermal resistance and response time of the heat pipe with Nano fluids decreased to 30% and 20% in comparison with water based fluid. In several textbook like Rey et al and kew et al or Faghri et al thermal performance, operation principles and design are discussed which belong to thermal performance enhancement of thermo syphon heat pipes working with Ag Nano fluid as working fluid.Vasilev et al and Kamotani et al demonstrated the reduced adverse effect of gravity by reducing the wick thickness in thermosyphon.Loh et al and coworkers showed the results that heat source orientation and gravity had less gravity effect on sintered powder metal heat pipe because of their strong capillary effect than mesh or groove heat pipe. Sugumar et al and Tio et al studied theoretically on an inclined-triangular and trapezoidal shaped micro heat pipe, based on their theoretical analysis from 0o to 60o angle the rate of heat transfer increased only at acute. The heat transfer of triangular micro heat pipe was noted to more than that of trapezoidal one.

II. PRINCIPLES OF OPERATION

Oscillating heat pipes may look simple but they are difficult to fabricate and are complicated devices to understand the oscillating heat pipe one must understand the driving thermodynamic operation, two phase oscillation flow governed by fluid dynamics and physical design parameters must be considered.

III. EXPERIMENTAL PROCEDURE

Heat transfer/ cooling strategies in comparison to CLPHPs. If a given heater block is to be cooled, thereby maintaining it at a fixed temperature, e.g. by convective aircooling (the external heat transfer coefficient is known and fixed), there are various techniques which may be adopted.. While the heat pipes may be made to operate at any inclination angle, since the capillary wick is the 'pump', (albeit with varying performance), traditional gravity assisted thermosyphons only operate in 'heater down' position. As far as the external air-cooling is concerned

Prior to the experiment start and charging of Nano fluid into oscillating heat pipe the apparatus was evacuated to 0.2 bar to draw the Nano fluid into copper pipe which has an aluminum mesh placed inside the copper tube along the inner circumference for 30 min using a vacuum pump connected to a valve which is used to isolate the vacuum pump and allow the Nano fluid into the copper pipe.

The evaporator is used to supply heat to the copper pipe by indirect heating by which we eradicate any accidents. The evaporator is given a constant heat input .

Thermocouples are used to measure the temperature at various parts of the system these measurements are displayed by the display system which is coupled to thermocouples.

IV. EXPEREMENTAL SET UP

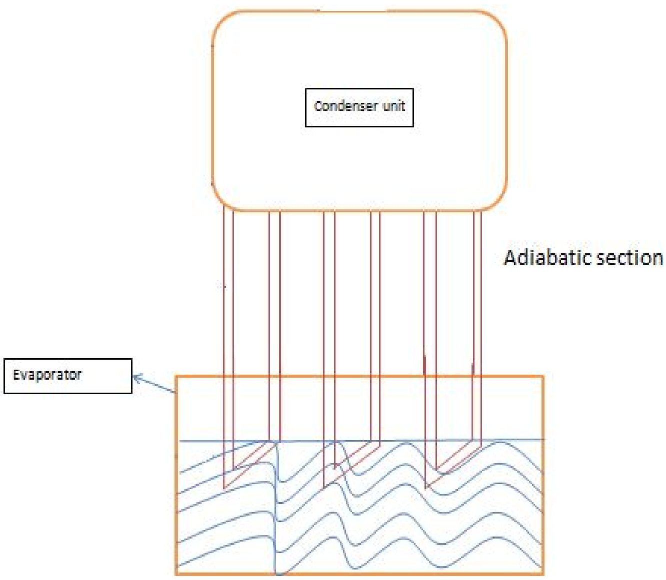

Fig 4.1 : Oscilating Heat Pipe

Table1

S.NO	VOLTAGE	CURRENT	NANO FLUID TEMPERATURE AT EVAPORATOR(^{o}C)		
	V	AMPS	T_1	T_2	T_{AVG}
1	100	1	34	33	33
2	100	2	39	39	39
3	150	2	45	45	45
4	160	2.5	49	49	49
5	200	2.5	51	51	51
6	200	3	55	55	55

Table2

SNO	VOLTAGE	CURRENT	NANO FLUID TEMPERATURE AT CONDENSER(^{o}C)		
	V	AMPS	T_3	T_4	T_{AVG}
1	100	1	31.5	31.5	31.5
2	100	2	32.5	32.5	32.5
3	150	2	34	33	33.5
4	160	2.5	36	36	36
5	200	2.5	38	38	38
6	200	3	40	40	40

Table3

SNO	VOLTAGE	CURRENT	RESISTANCE OFTHE NANO FLUID
	V	AMPS	^{o}C/WATTS
1	100	1	0.0015
2	100	2	0.0325
3	150	2	0.0383
4	160	2.5	0.0325
5	200	2.5	0.026
6	200	3	0.025

V. RESULT AND DISSUSION

The heat transfer coefficient at condenser ansd evaporator is calculated by using

$$Q=hA\Delta T$$

Where Q is the heat input, his the heat transfer coefficient, A is the cross-sectional area of the evaporator and condenser, ΔT is the temperature difference between condenser and evaporator sections from the above equation we can find heat transfer coefficient

The resistance can be calculated by using the equation

$R=Te-Tc/Qin$

Ris the resistance of the fluid, Te is the temperature at the evaporator,Tc is the temperature at the condenser ,Qin is the heat input

$Q= V*I$

V is the voltage and I is the current.

$h=Q/A\ \Delta T$

The vaoltage and current are regulated by using the electrical means or by using mechanical means.Te and Tc is caluculated by thermocouples. By taking these two readings we can caluculate the heat transfer coefficient

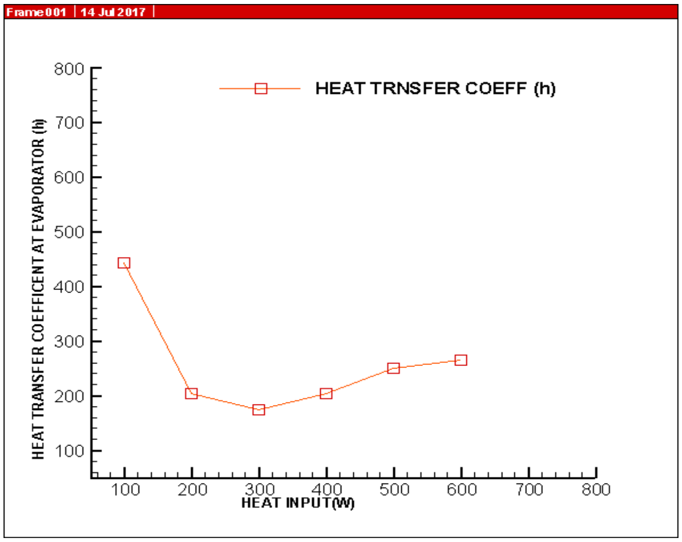

Figure 2: Variation of heat transfer coefficient

From Figure 2 the heat transfer coefficient decreases up to heat load of 300 watts and increases from 300 watts to 600 watts. It is due to the increases of difference in temperature ΔT. Where ΔT is indirectly proportional to heat transfer coefficient (h).

$$Q/A\Delta T=h$$

$$h\alpha 1/\Delta T$$

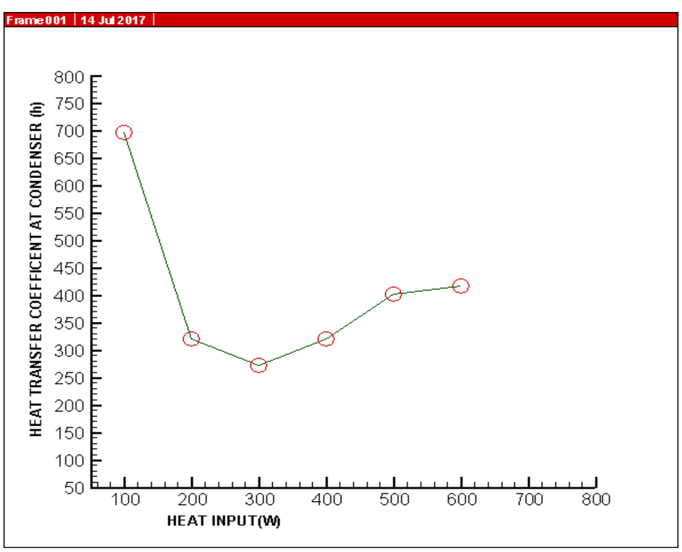

Figure 3: Variation of heat transfer coefficient

By this figure 3 we can identify the same result as the above figure 2 with the variation of the same heat loads.

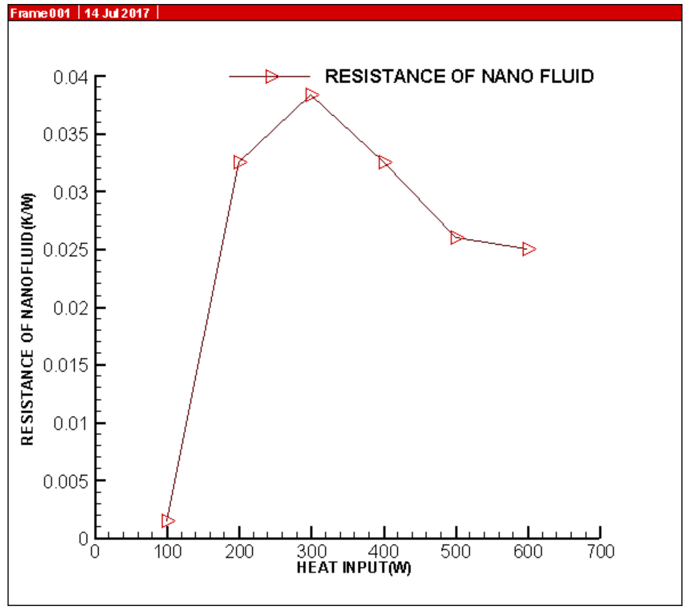

Figure 3: Change in resistance with respect to heat input

The resistance of the nano fluid behavior is given by the above Figure 3. The resistance of the nano fluid increases up to heat input of 300watts and decreases from 300 watts to 600 watts gradually

VI. CONCLUSIONS AND FUTURE WORK

An experimental study was conducted to evaluate the heat transfer enhancement of the Iron Oxide (gamma – Fe2O3 – high purity) dispersed nanoparticles into the Kerosene as the base fluid in an oscillating heat pipe. From the experimental findings, the following conclusions could be drawn:

- The thermal resistance, heat transfer performance and the heat transfer coefficient of the OHPs apparently improved after using the Nano fluids, and this increased efficiency was higher for theNano fluids of Fe2O3 under the magnetic field. The results indicated 16% increase in the heat transfer performance.
- The difference between the surface and the vapor temperature reduced significantly when the Fe2O3 was used. Maximum differences of 2 _C and 3.1 _C were observed in the evaporator section of the copper OHP under the magnetic field, and for the Nano fluid without the magnetic field, respectively.
- The increase in the input heat flux led to an increase in the heat transfer coefficients of the evaporator and the condenser.

- The surface temperature was more than the vapor temperature in the evaporator, while it was less than the vapor temperature in the condenser.

However, although by increasing the weight percentage of Nano-particles in the fluid suspension, the heat transfer rate will be enhanced, but it will be along with reducing the movement of bubbles which can lead to ducts blocking and increase the pressure drop in the system. Therefore, in a future work the plan is to find the optimum percentage of nano particles for using in an OHP under magnetic field.

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