Experimental Investigation of Pulsating Heat Pipe For Air Conditioning System

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Abstract- *Cost effective air conditioning system is the need of current era as many competitors are present in the market. Also the main aim of the air conditioning is to provide best suitable results with the minimum cost and feasible modifications. The present work focuses on the use of pulsating heat pipe instead of conventional cooling coil. Conventional cooling coil and compressor consumes higher amount of power and greater maintenance is required for it. Conventional Air conditioner work on Vapor compression cycle and utilizes the compressor and working fluid. Compressor increases pressure and temperature of working fluid i.e. refrigerant. The high power consuming compressor is replaced by the pulsating heat pipe and due to this elimination of excessive power consumption is possible. Also the issue of noise and maintenance of the compressor is resolved with this modified system*

Keywords- Vapor Compression Cycle, Heat Pipe. Modified AC System

I. INTRODUCTION

Air conditioning is a process that simultaneously conditions air; distributes it combined with the outdoor air to the conditioned space; and at the same time controls and maintains the required space's temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing, or both.

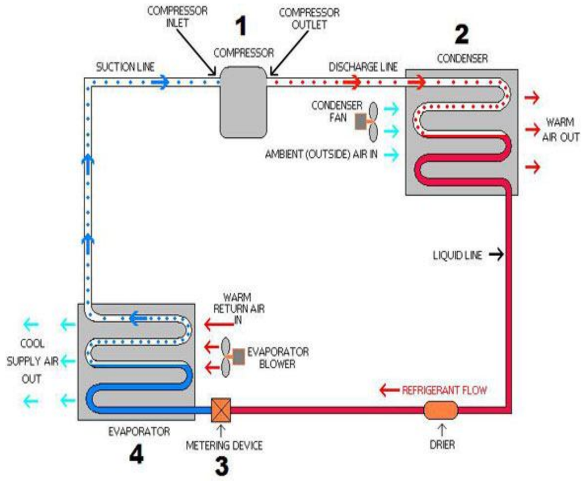

Figure: - Schematic Diagram of Vapor Compression System

[A] Compressor: Compressor is the device used to compressor low-pressure vapor of refrigerant to high temperature and pressure

[B] Condenser: Condenser will reject the heat into outside atmosphere so that high-temperature refrigerant vapors convert into the high-temperature liquid refrigerant.

[C] Metering Device: Metering device is basically a capillary tube. It will adjust the flow of refrigerant through the evaporator and maintains the temperature of outlet air.

[D] Evaporator: Evaporator receives the low-pressure liquid refrigerant from the Metering device and absorbs the heat of inlet air.

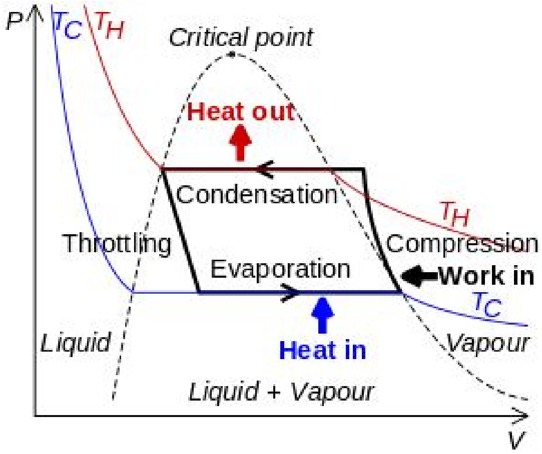

Figure: - Vapor Compression Cycle

1.1 Two Phase Passive Systems

The operation of modern passive heat transfer devices is based on the combined action of three physical phenomena: phase-change, gravity, and capillarity.

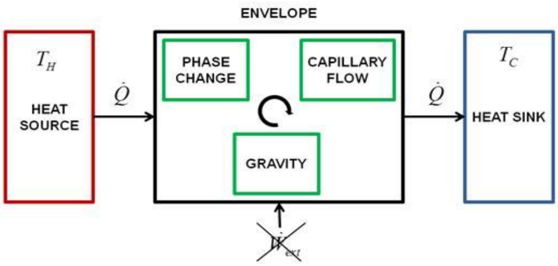

Figure: General Schematic of Two-Phase Capillary Driven Heat Transfer Device

II. LITERATURE REVIEW

Our primary objective is to study the alternative method or device for achieving the objective of power consumption reduction and maintenance of the compressor by replacing it by such efficient device.

Smyrnov G.F et al. [1] studied the use of this is made in the refrigerating device. Akachi. H. [2] suggested a new variant of the PHP construction. twenty-four different preferred embodiments of what is referred to as Loop Type Heat Pipe were described. Khandekar et al. [3] conducted experiments on a PHP made of a copper capillary tube of 2-mm internal diameter. The working fluids used are water, ethanol, and R-123. The PHP was tested in horizontal and vertical bottom heat mode orientation. Piyanun Charoensawan et al. [4] conducted experimental investigations on a range of PHPs. The closed loop PHPs were made of copper tubes of inner diameters 2 mm and 1 mm. Zhang X. M. et al. [5] present the experimental study on PHP using FC–72, ethanol and water as working fluids. The experimental setup consists of copper tubes of inner diameter 1.18 mm and the number of turns was 3. Khandekar et al. [6] In order to study fundamental design equation for pulsating heat pipe and describe experimental results of the closed loop valve less pulsating heat pipe with the effect of heat inputs flux and filling ratio on the thermal performance of the device. Shi LIU Jingtao LI et al. [7] A series of the experiment are performed on three types of closed loop pulsating heat pipes (PHPs), indenting to investigate various kinds of flow patterns, and to develop some improved configurations for the PHPs.

III. METHODOLOGY

Experimental Methodology

On Closed loop pulsating heat pipe hot air is feed over the evaporator section and air will reject heat to CLPHP. Inside the CLPHP the Refrigerant name as Pentane (C_5H_{12}) will caries this heat to Condenser section and rejects this heat to cooling medium; that is Water. This Condenser water gets cooled with help of cooling tower.

[a] Working Fluid

Selection of working fluid is avery important step in development of heat pipe air conditioning system

[b] **Pentane (C_5H_{12})**

The working fluid use is Pentane, having a boiling point around 35 °C

[c] **Closed loop PHP**

Heat Pipe Air Conditioning system consists of 10 closed loop Pulsating Heat pipes (CLPHP) is made of copper tube. Each CLPHP has a 2.1mm internal diameter and 3.0mm external diameter. The length of evaporators and condenser section is keeping same; that is 450mm each. The PHP has 19 tunes and Consists of One Non-return valve.

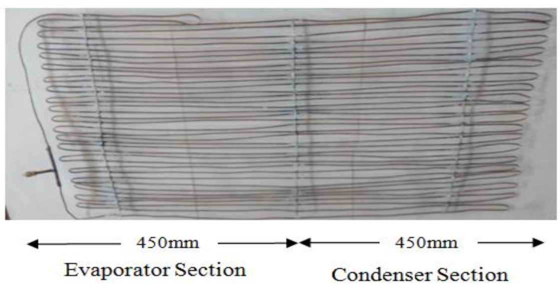

Figure: - Closed Loop PHP

[d] Cooling Tower

The cooling tower is used to reject heat into the atmosphere, so that keep condenser water temperature low.

Figure: - Cooling Tower

[e] **Cooling Fan**

Cooling fans are used to create an air current and to force the air over the evaporator section of CLPHP.

[f] **Thermocouples**

In this system, eleven thermocouples (K type) have been used in the experiment. Three have been located on the Evaporator section and three over the Condenser section.

[g] **Thermocol**

Thermocol is an insulating material used to avoid loss of heat. It prevents the outside air to transfer heat to walls of evaporator section and avoid the contact of inlet air with outside walls.

[h] **Ducts**

Two separate ducts are made of GI steel sheets are used to forma body of Air Conditions system.

Figure: - Arrangement of CLPHPS with a dividing plate and Condenser Section duct.

Figure: - Experimental Set Up

[A] Statistical Modeling of Heat Pipe Air Conditioning System

Effect of Temperature of Inlet Air over Coefficient of Performance for Indoor Operating Condition

$$COP (T_{in}, T_{out}) = 5.33 * 10^{-15} + (0.461) T_1 + (-0.461) T_2$$

Effect of Temperature of Inlet Air over Coefficient of Performance for Window Operating Condition

$$COP (T_{in}, T_{out}) = 5.33 * 10^{-15} + (0.922018) T_1 + (-0.92202) T_2$$

IV. RESULTS

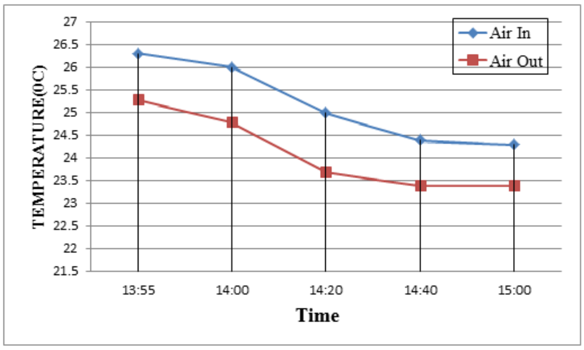

Figure: Change in temperature of Inlet and Outlet air with time for Indoor operating condition

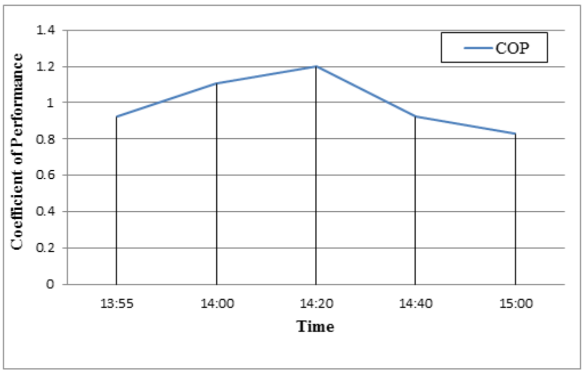

Figure: Change in COP with time for Indoor operating condition

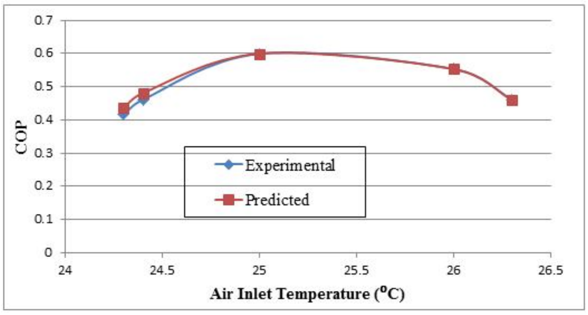

Figure: COP Vs Air Inlet Temperature for Indoor Operating Condition

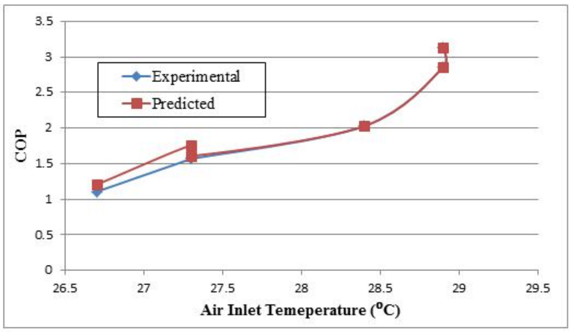

Figure: COP Vs Air Inlet Temperature for Window Operating Condition

V. CONCLUSIONS

In the present work, the experimental analyses are carried out on a nineteen loop PHP with pentane as working fluid.

From these experimental analyses the following conclusions are drawn:

[1] It creates a cooling effect around 5 °C and effectively delivers cold air at comfort air temperature of 25°C.
[2] The indoor operating conditions give more satisfying results than window and outdoor condition.
[3] The power consumption is about 109 Watts and this power consumption is lower than one ceiling fan. The quantity of water required for producing this much of cooling effect is about only 3 to 4 liters per day. Hence, there is a huge saving of water and Electricity.

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