# Review of Pulsating Heat Pipe for AC Applications

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**Abstract**

*An intense literature review is carried out to find the performance of the current heat pipe systems for air conditioning and many more applications. In air conditioning systems, the researchers mainly concentrated on the use of heat pipe heat exchanger as a unit for humidity control and heat recovery. The review shows that by the use of a heat pipe heat exchanger in air conditioning systems, the moisture removal capability and energy saving was increased in addition to the environmental impact. In other applications such as personal computers application, the use of heat pipes makes it possible to create low-noise and effective systems for cooling of personal computer components under high thermal load. On the basis of results obtained from the reviewed research studies, the application of heat pipes is recommended in air conditioning systems.*

**Keywords:-** *Heat Pipe, Air Conditioning System, Heat Exchanger*

## I. INTRODUCTION

Air conditioning is an active, rapidly developing technology. It is closely related to the living standard of the people. Now a day there is the great short stage of Electricity in India and Use of Air Conditioner is essential in Indian climatic zone. The capital and running cost of these air conditioners is very high, and maximum people in India are below poverty level and will not able to afford it. This is the reason that people preferred Desert cooler instead of Air Conditioner. But desert coolers required large amount of water for its operation. It is expected to develop a highly cost effective Air Conditioner with the use of pulsating heat pipe instead of cooling coils. In conventional Air conditioner work on Vapor compression cycle with use of Compressor for increased pressure and temperature of working fluid, that is refrigerant. The compressor is very high power consuming device and needs a great amount of electrical energy. The main objective of this work is to eliminate the use of high power consuming compressor and use a pulsating heat pipe instead of cooling coils. Eliminating use of compressor will definitely reduce the power consumption, and use of pulsating heat pipe will cause the flow of refrigerant without any external power.

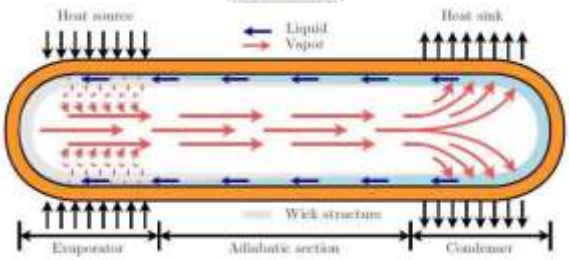


**Figure 1: - Conventional Heat Pipe**

Typical heat pipe consists of three main sections, which include an evaporator region, an adiabatic region, and a condenser region. Heat added to the evaporator section vaporizes the working fluid, which is in equilibrium with its

own vapor. This creates a pressure difference between evaporator section and a condenser section, which drives the vapor through the adiabatic section towards the condenser section. At the condenser section, heat is removed by condensation and is ultimately dissipated through an external heat sink. The capillary effect of the wick structure will force the flow of the liquid from the condenser to the evaporator section. A heat pipe consists of three main parts, which are the vessel, wick structure, and working fluid. The vessel or a container is normally constructed from glass, ceramics or metal. Where else wick structure is constructed from sintered metal powders, wire meshes, or grooves. Finally, the typical working fluid used varies vary from nitrogen or helium for low-temperature heat pipes to lithium, potassium or sodium for high temperature. In order to fabricate working heat pipes, all three parts are given important consideration to the material type, thermophysicalproperties, and compatibility. The heat pipe is capable of creating its own capillary pressure at the evaporator end. This would cause a continuous flow of liquid in the wick and replenish the liquid at the evaporator zone. Heat flows through evaporator section and condenser section assumed to be adiabatic. Due to this reason, the vapor experiences a negligible temperature drop. Generally, heat pipes exhibit thermal characteristics that are even better than a solid conductor of the same dimension. As for wick structure, the working fluid travels from the condenser section to the evaporator section.

## II. LITERATURE REVIEW

The history of air conditioner started in the early days with the need to preserve foods. Foods that are kept at room temperature spoil easily due to the growth of bacteria. At temperature below 4° C (40° F), the growth of bacteria is reduced rapidly. As a result of the development in food refrigeration, other applications that follow include air conditioning, humidity control and manufacturing processes.

The discovery of the principles of the absorption type of refrigeration in 1824 showed that liquefied ammonia could chill air when it is allowed to evaporate. Ice was created using compressor technology in the year 1842 by a physician named John Gorrie.

**History of Air Conditioners and Refrigeration**

**[1] 1820** Ice was first artificially made as an experiment.
**[2] 1824** Michael Faraday discovered the principals for absorption type of refrigeration.
**[3] 1834** Jacob Perkins invented the first artificial ice manufacturing machine which led to our modern vapor compression system.
**[4] 1902** Willis Haviland Carrier invented the first air conditioner to control the temperature and humidity of a printing company, making the first time effort taken to control the temperature of surroundings.
**[5] 1906** Stuart W. Cramer comes out with the term "air conditioning"; which was later adopted by Carrier.
**[6] 1913** The first international refrigeration expo is held in Chicago.
**[7] 1928**The discovery of Freon refrigerant by Thomas Midgley, Jr.
**[8] 1957** The first rotary compressor was developed hence making air conditioning units smaller and more efficient compared to the reciprocating type.
**[9] 1977** Heat Pumps equipment developed that allows cooling and heating cycle using the same machine that can be used to provide cooling during summer and heating during winter.
**[10] 1987** Montreal Protocol signed to protect the earth's ozone layer is signed in Montreal, Canada. The Protocol establishes international cooperation on the phase out of ozone depleting substances, including the chlorofluorocarbon (CFC) refrigerants used in HVAC equipment.
**[11] 1990** Microprocessor control systems are used in all areas of refrigeration and air conditioning due to the readily available semiconductor technology.
**[12] 1992** The R-22 Alternative Refrigeration Evaluation Program (AREP) starts to find alternative refrigerants to R-502 and R-22.
**[13] 1997** Kyoto Protocol signed to protect the earth's climate by reducing greenhouse gases that cause climate change.
**[14] 2007** A State Council issued a circular to restrict the temperature of air conditioning in public buildings to 26°C or higher during summer and 20°C and lower during winter

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. Honghai Yang et al. [8] presented an experimental study on the operational limitation of closed loop pulsating heat pipes (CLPHPs). It consists of a total of 40 copper tubes with 1 mm and 2 mm internal diameter respectively. P. Meena et al. [9] studied the effect of evaporator section lengths and working fluids on the operational limit of closed loop oscillating heat pipes with check valves (CLOHP/CV). It is experimentally concluded when the evaporator lengths increased the critical heat transfer flux decreased. Yu-Hsing Lin et al. [10] studies and measured the efficiency by comparing 20nm silver Nano-fluid at different concentration (100ppm and 450 ppm) and variable fill ratio (20%, 40%, 60%, 80%, respectively), and applying heat input power from 5W to 85W in steps up of 10W. ase flow patterns. M. Mameli et al. [11] studied experimentally the wide range of pulsating heat pipe and then partially filled with working fluid. Important parameters i.e. local fluid and wall temperatures and corresponding internal pressure fluctuations have been recorded and visualized the internal two-phase flow patterns. K. Rama Narasimha et.al. [12] carried out the experiments on single loop pulsating heat pipe for different heat input power, working fluids and for different evacuation levels. The evaluated parameters are thermal resistance and heat transfer coefficient of PHP. Pramod R. Pachghare et al. [13] presented an experiment on a thermal performance of closed loop pulsating heat pipe (CLPHP). The capillary tube is made up of copper having inner and outer diameters are 2.0 mm and 3.6 mm respectively. For complete experimentation, filling ratio (FR) = 50 %, the number of turns was 10 and different heat input power of 10 to 100 W was supplied to PHP. The lengths of evaporator, adiabatic and condenser sections were of equal i.e. 50 mm each. The different working fluids are used as Methanol, ethanol, acetone, water and different binary mixtures of the working fluids. Gi Hwan Kwon et.al. [14] performed a series of experiments to investigate the effect of a dual-diameter tube on the flow and heat transfer characteristics of single-turn pulsating heat pipes (PHPs). Various types of PHPs were made of glass capillary tubes with various inner diameters.

Anderi Burlacu et al. [15] focused on developing a heat pipe heat exchanger for domestic hot water and thermal agent preparation, preheating / heating the air from ventilation systems in buildings, using as a primary agent the return of the existing heating system.

**[A] Findings from Literature Review**

[1] Some of the researchers had worked on the pulsating heat pipe

[2] Many of the researchers had worked on the use of conventional cooling coils in air conditioner

[3] Some of the researchers studied the air conditioning system which work on the vcc cycle with the use of compressor and refrigerant

[4] None of the researchers had studied the vertical pulsating heat pipe

## III. CONCLUSIONS

[1] It can create a cooling effect around 5 °C and might effectively deliver the cold air at comfort air temperature of 25°C.

[2] The indoor operating conditions may give more satisfying results than window and outdoor condition.

[3] The power consumption will be reduces to around 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 can be a huge saving of water and Electricity.

[4] This system may work with high COP about 3.7, which is more than 5-star rating Air Conditioners available in Indian market.

[5] With the current system, there can be 90% saving in energy consumption. The size of the current system is very bulky. In a size of 1 tonne of Air Conditioner, this system creates only 10% results