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*Research Paper*

# EVALUATION OF THE THERMAL PERFORMANCE OF HEAT PIPE HEAT EXCHANGER UNDER NATURAL CONVECTION

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An analytical model will be developed to evaluate the thermal performance of a Heat Pipe Heat Exchanger (HPHE) under natural convection by adopting thermal resistance approach. The model evaluates the rate of heat transport and pressure drop across evaporator system of the HPHE under natural convection. The model computes various thermal resistance of the heat pipe at the external surface of evaporator and condenser as well as the internal surface of the heat pipe based on the correlations available in the literature. The rate of heat transport will be calculated by converting the model into a computer programme whose solution is based on an iterative procedure. The analytical model validated on a single heat pipe will extend to the HPHE by incorporating appropriate geometrical and heat transfer co-relations. Another test rig will be developed for evaluating the thermal performance of a HPHE under natural convective cooling condition as well as for validating the analytical model. The experiment will be conducted on the HPHE under natural convective condition at different tilt angles form the horizontal (150, 250, 300 and 900) and at various heating fluid temperatures (40 °C, 50 °C, 60 °C and 70 °C) at its evaporator inlet. The Reynolds numbers of heating fluid in the evaporator section will varies in the any range of Reynold Numbers. The variation of ambient surrounding temperature will also be considered. The heat transport rate of the HPHE should be increases marginally as the Reynolds number of heating fluid increases in the evaporator section because the condenser heat transfer coefficient does not increase significantly. The maximum heat transport rate from the HPHE will be obtained at any tilt angle and any heating fluid temperature.

***Keywords:*** Heat pipe, Evaporator, Condenser

## INTRODUCTION

Thermal system are commonly associated with diffrent types of heat exchangers, based on sensible heat transfer, latent heat transfer and mixed mode of these two types. These include shell and tube type, cross flow heat

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exchangers, evaporators, condensers, and heat pipe heat exchanger, etc. The motivation for using heat pipe heat exchangers is to obtain high exchanger compactness in given box-volume having weight limitations. Energy systems manufacturers normally offer the base systems, which are used in a variety of engineering applications. For conversion of these base systems into a complete one, the manufacturers normally depend upon the local vendors for procurement of accessories including heat exchangers, which may not be optimally designed. Since these heat exchangers are to be adopted in a new configuration and layout, therfore, even well designed heat exchangers in a particular configuration are subject to change in effectiveness. To enhance the effectiveness of the sensible heat exchangers, one may look for a variety of solutions in the given situation. One of the solutions may be increasing the surface area of heat transfer, which increase the size of the heat exchanger, whereas, the other solution may be increasing the flow rates of the fluids involved, which results in more pressure drops of the fluids. The first option needs more space, whereas, the second may not be permitted by virtu of design implications. In the recent past, Heat Pipe Heat Exchangers (HPHE) have been used in various thermal systems for improving their effectiveness. Most of the studies on these exchangers are limited to forced convection but a little work has been reported in the natural convection conditions. Therefore, the present work aims at conducting reserch on heat pipe heat exchangers under natural convection conditions.

In Fiugre 1 the overall thermal resistance of a heat pipe determines its thermal performance.

In radial direction, these resistances occur at the interface of heat source and external heat pipe wall in heat pipe wall, liquid wick interface, liquid vapour interface at evaporator and condenser, and the external condenser section of heat pipe and heat sink or surrounding.

In axial direction, the thermal resistance occur in pipe wall depending on design (smooth tube, grooved tube, liquid saturated wick at all wall), in liquid and liquid saturated wick and vapour core between evaporator and condenser. In many of the application, the combination of resistance occurring between heat source and evaporator and condenser and heat sink are of the same order as the overall thermal resistance of a heat pipe.

## HEAT RECOVERY SYSTEM USING HPHE IN DRYING CYCLE

Theoretically investigated the effect of a loop heat pipe air handling coil on the energy consumption in a central air conditioning system with return air for an office building. Based on the results, the air conditioning system installed with HPHE could save cooling and reheating energy.

The Rate of Energy Saving (RES) is defined by:

$\bullet = Q - Q'/Q$

Where Q is the cooling load or total energy consumption in a central air conditioning system with returned air at constant indoor design temperature (Kw) and $Q'$ is the cooling load or total energy consumption with HPHE at constant indoor design temperature (Kw).

**Figure 1: Heat Pipe Operation**

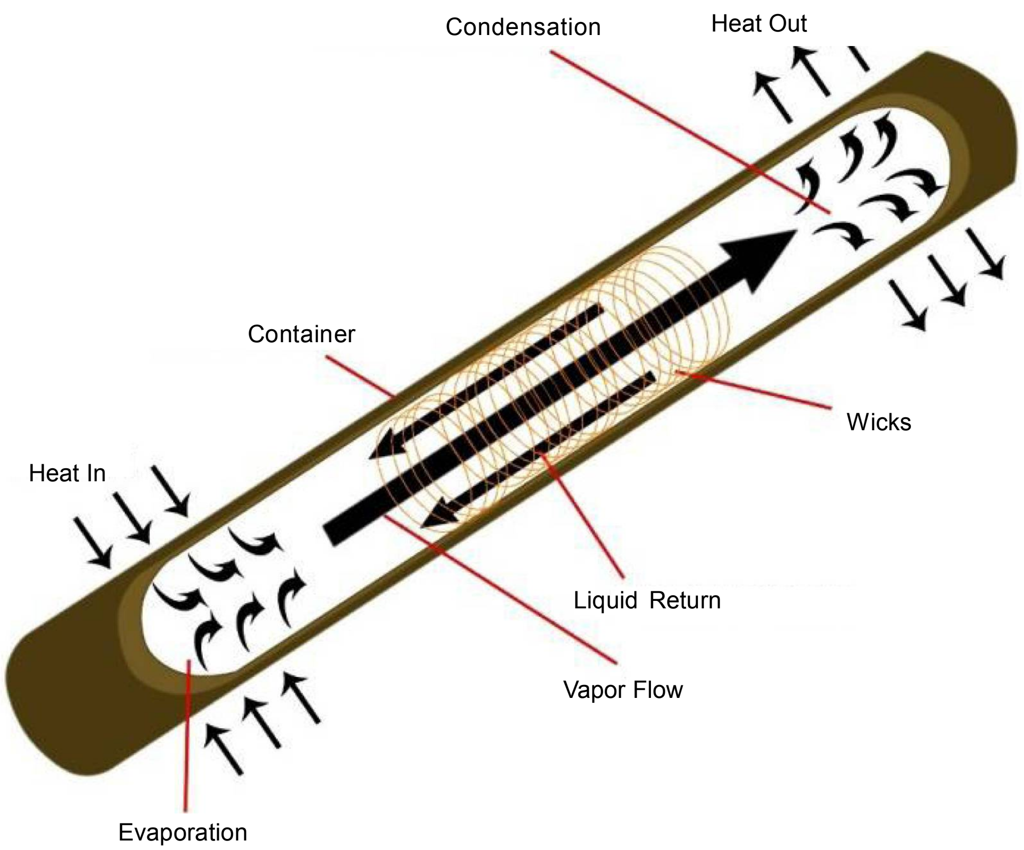
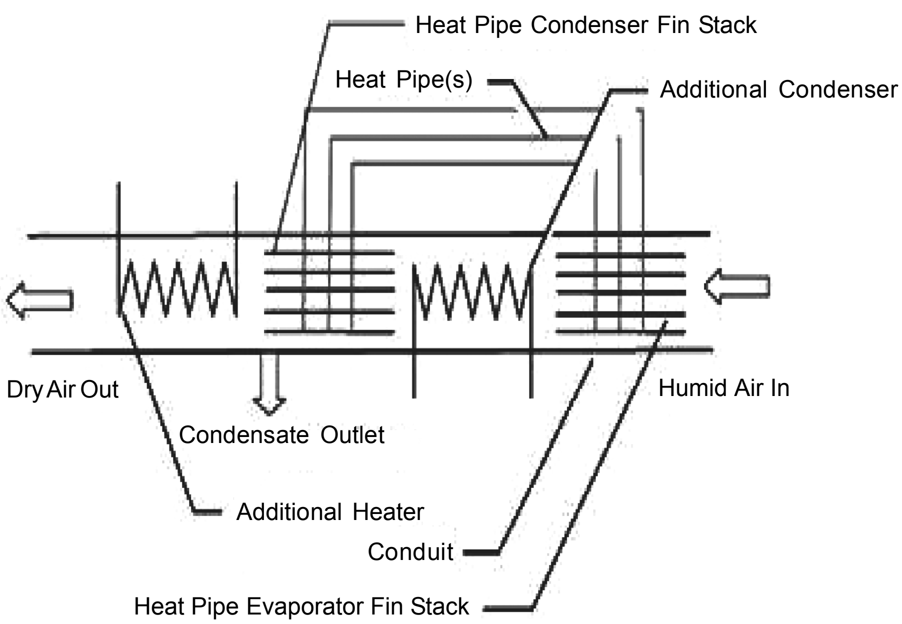



**Figure 2: Heat Recovery System Using HPHE in Drying Cycle**



In the temperature range of 22 to 26 °C indoor design and 50% relative humidity, the rate of energy saving in the office building was 23.5 to 25.7% for cooling load and 38.1 to 40.9% for total energy consumption.

In Figure 2 the rate of energy saving was increased with the increase of the indoor design temperature and decrease of indoor relative humidity. The study demonstrated that by employing a HPHE in an air conditioning system, the energy consumption could be significantly reduced and the indoor thermal comfort and air quality also could be improved.

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