CHAPTER I

INTRODUCTION

The heat pipe is a high performance heat transfer device which can effectively be operated over a small temperature gradient. The concept of heat pipe was first suggested by R.S.Gaugler in 1942. There was no experimental investigation to support his concept until 1963 when Grover and his coworker reinvented this concept. The first heat pipe was then constructed and its effectiveness as a heat transfer devices demonstrated. Since then, the heat pipe have been developed and used in various applications. (1)

The heat pipe (Figure 1.1) generally consists of a sealed tube whose inner wall is lined with a capillary wick structure. Except for a selected amount of working fluid, the tube inside is under vacuum. Heat applied to the lower end of the heat pipe causes the working fluid inside the tube to vaporize. Then the vapor flows to the other end and condenses there, as it releases the latent heat of condensation. The condensate is returned by capillary action to the evaporator section to revaporize and complete the cycle.

The heat pipe operates on a condensation/evaporation cycle which is continuous as long as there is a temperature difference to drive the process.

In cases where the condensation section is elevated, the condensate is returned by gravity, and no wick is necessary. In such cases the heat pipe is called wickless heat pipe or thermosyphon (Figure 1.2). Besides the capillary and gravitational forces, other

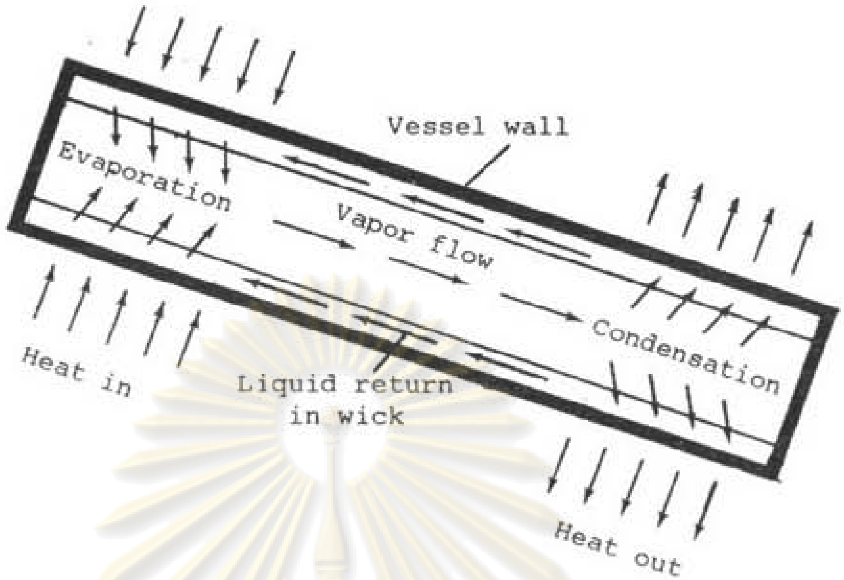

Figure 1.1 Basic operation of the heat pipe

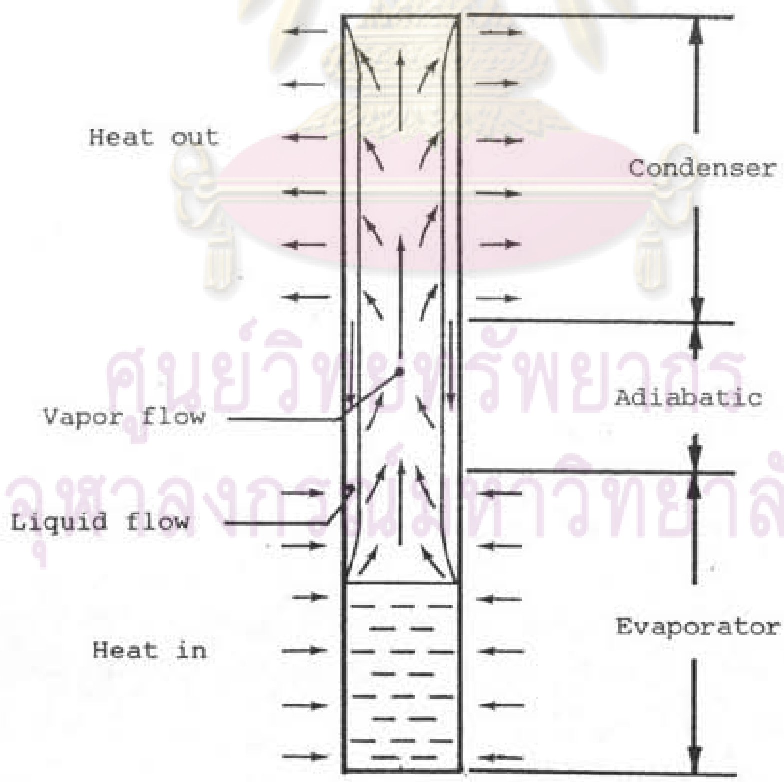

Figure 1.2 Basic operation of the closed two-phase thermosyphon

external forces can be used for returning the condensate to the evaporator, such as centrifugal force, osmotic force, etc., which are listed in Table 1.1 (2).

Table 1.1 Methods of condensate return

Force	Type
Gravity forces	Standard thermosyphon
Capillary forces	Standard heat pipe
Centrifugal forces	Rotating heat pipe
	Rotary heat pipe
Electrostatic volume forces	Electrohydrodynamic heat pipe
Magnetic volume forces	Magnetohydrodynamic heat pipe
Osmotic forces	Osmotic heat pipe
Vapour bubble pump	'Inverse' thermosyphon
Mechanical pump	Two - phase run around - coil

Because of its advantages, heat pipe has been used in a wide variety of applications, such as maintaining uniform temperature in bakers'ovens, cooling electronic circuit packages, cooling thermoelectric devices, internal cooling of gas turbine blades, cooling electric motor rotors, precooling of cryogenic equipment, etc (3). The list of applications is quite long but one attractive application is to use as heat transfer elements in heat exchangers for heat recovery units. Heat-pipe heat recovery units can be used to recover heat in exhaust gases from industrial processes and HVAC systems. In the present investigation, the thermal performance of the wickless heat pipe have been investigated experimentally, then thermal design of the heat-pipe heat exchanger carried out based on the experimental data.

1.1 The Objectives of the Thesis

The following objectives were set.

1. Study and test the thermal performance of individual wickless heat pipes experimentally to obtain useful data for heat exchanger design.

2. Study the effects of inclination angle, amount of working fluid, flow rate of hot and cold streams and the temperature gradient on the thermal performance of the wickless heat pipes.

3. Design a heat-pipe heat exchanger for recovering cold energy in ventilated air from air-conditioning system based on the above results.

1.2 The Scope of Work

In order to achieve the objectives mentioned in section 1.1, several wickless copper-freon heat pipes were constructed using either Freon-22 or Freon-113 as working fluid. The experimental set-up was designed and constructed, then the heat pipes were tested individually by varying the flow rates of the hot and cold waters, the inclination angle, and the temperature difference between the hot and cold sections. The data obtained from the experiments were analyzed and interpreted by using existing information and correlations. Finally a heat pipe heat exchanger, for use in a gas-gas heat recovery system was designed using the above experimental data.