Heat Transfer of a Heat Pipe on fins using Silver nanofluid

P. Meena[1*], A.Sangmart[1]
[1] Energy Innovation and Heat Pipe Technology Research Unit (EIHTR), Department of Physics, Faculty of Science, Mahasarakham University, Thailand 44150, Thailand

*E-mail: pattanapol.m@hotmail.com

Abstract. This research aimed to determine the heat transfer rate of the heat pipe using Silver nanofluid as a working fluid. The closed loop oscillating with check valvs in this study was made of copper. The copper tubes and fins have an outside diameter of 5.16 mm. The lengths of the evaporator, adiabatic and condenser section of heat pipe are 200, 100 and 200 mm, respectively. The radians of fins is 0.5 cm. The CLOHP/cv had 24 tubes with Silver-nanofluid as the working fluid, and a filling ratio 50% of total volume. The evaporator section was heated by a heater, while the condenser section was cooled by fresh air. The hot air was controlled to 60 70 and 80 degree Celsius, and the fresh air velocities were adjustable to three levels: 0.5, 1.0 and 1.5 m/s. The test operation was focused on the heat transfer rate and thermal effectiveness of the CLOHP/cv. It was found that the maximum value of the heat transfer rate and thermal effectiveness occurred when the air velocity and hot air temperature were 0.5 m/s and 80 degree Celsius, respectively.

1. Introduction

Oscillating heat pipe is a very effective heat transfer device with can even if the difference in temperature between the heat sources is less has been developed. OHP had 3 type of closed end oscillating heat pipe, closed-loop oscillating heat pipe and closed-loop oscillating heat pipe with check valves, and OHP has three sections of evaporator, adiabatic and condenser sections of heat pipe, which a closed-loop oscillating heat-pipe with check valves (CLOHP/CV). This type is a closed loop oscillating heat pipe, in which both ends of the capillary tube are connected to form a closed-loop. The loop has one or more check valves for control the working fluid in a tube[1-2]. In years resent, Meena and Rittidech [3-4] study aims to design, construct and test waste heat recovery by closed-loop oscillating heat pipe with check valve from pottery kilns for energy thrift. The CLOHP/CV heat exchanger can reduce the quantity of using gas in pottery kilns and achieve energy thrift. And CLOHP/CV has into application about air-preheater for reduced relative-humidity in drying systems[5]. A new generation of heat transfer fluid in heat pipe has inclusions of nanoparticles into a base fluid significantly increasing the thermal properties of the base fluid [6-9].

Thus, in this study investigated characteristics of heat transfer rate and its effectiveness of closed-loop oscillating heat pipe with check valves (CLOHP/CV) on fins at heat mode. To check on heat transfer rate needed to focus on working fluid, evaporator temperature, air velocity, All heat exchangers used silver nano as working fluids. The radiuses of fins was 0.5 cm. this study focuses on determining the actual thermal performance of closed-loop oscillating heat pipe.

2. Theoretical consideration and Experimental details

2.1 Heat transfer characteristics of the CLOHP/CV

Determination of the heat transfer to the condenser section is calculated by the calorific method. By measuring temperature of the inlet and outlet of the heating fluid, the condenser values can be calculated using the following equation:

$$Q = \dot{m} C_p (T_{out} - T_{in}) \quad (1)$$

Where Q is the heat transfer rate (W), $\dot{m}$ is the mass flow rate (kg/s), C_p is the specific heat (J/kg-ºC), T_{in} is the inlet temperature (ºC) and T_{out} is the outlet temperature (ºC).

$$q = \frac{Q}{A_c} = \frac{Q}{\pi D_o L_c N} \quad (2)$$

Where q is the heat flux (W/m^2), D_o is the outside diameter of the tube (mm), L_c is the length of condenser section (mm) and N is the number of rods in the heat pipe condenser section

$$\varepsilon = \frac{Q_{act}}{Q_{\max}} \quad (3)$$

2.2 Experimental details

Design and construction of the test rig and construction of the CLOHP/CV heat exchanger with fin is shown in Fig. 1. The length of evaporator, adiabatic and condenser section of heat pipe was 20, 10 and 20 cm respectively. The CLOHP/CV was made from copper pipe, and the capillary tube had a 5.0 mm inside diameter. There were 24 meandering turns with 2 check valves. The CLOHP/CV with Annular coper fin was 0.5 cm, thickness was 1 mm, with using silver-nanofluid as the working fluid, and a filling ratio 50% of total volume.

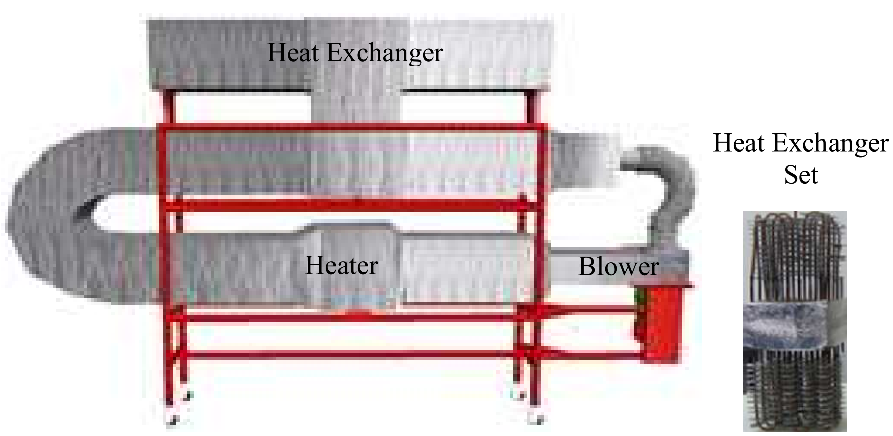

Fig.1. The CLOHP/CV heat exchanger test rig.

Installation of the trial CLOHP/CV with experimental equipment and instrumentation is shown in Figure

1. The instruments were thermocouples (type K) at the air inlet and outlet of the heat source and at the air inlet and outlet of the evaporator section and condenser section. The thermocouples were plugged into the data Logger (Agilent Technologies 34970A). The 34970A Features $6^{1/2}$ digits (22 bits) of resolution, 0.004% basic dcV accuracy for data to be analyzed in the next step. Which heating by heater which is attached in the evaporator section and controlled temperature hot air of evaporator section was 60, 70 and 80 degree Celsius. The cool air is region the condenser section of heat pipe. This controlled the velocity as 0.5, 1.0 and 1.5 m/s by inverter. The cool air is allowed to flow through the condenser to cooling the CLOHP/CV.

3. Results and discussions

3.1 Effect of temperature and velocity to the heat flux and the effectiveness of CLOHP/CV on fin

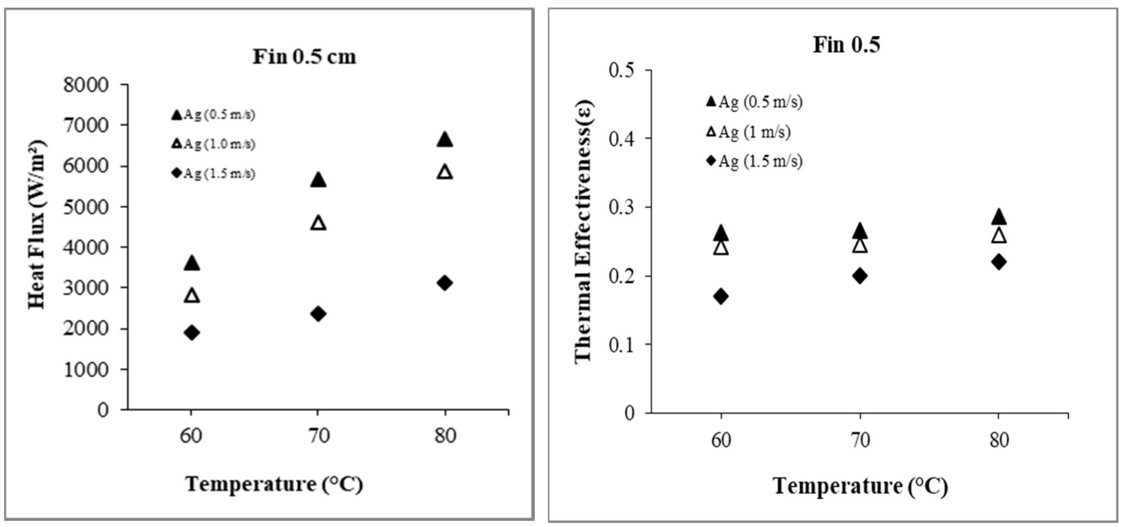

Figure 2, 3 Effect of temperature and velocity to the heat flux and thermal effectiveness of CLOHP/CV

A figure 2. Shows the effect of temperature and velocity to the heat flux of CLOHP/CV on fins using Silver nanofluid as working. To check on heat flux needed to focus on evaporator temperature and velocity. The hot air temperature at 60, 70 and 80 degree Celsius, while the air velocity at 0.5, 1.0 and 1.5 meter per second, from the experiment it was found that the heat flux of the heat exchangers was the best, when using the air velocity at condensed part at 0.5 meter per second, temperature at 80 degree Celsius, heat flux exhibited 6676.76 W/m^2.

A figure 3. Shows the effect of temperature and velocity to the effectiveness of CLOHP/CV on fins using Silver nanofluid as working. To check on effectiveness needed to focus on evaporator temperature and velocity. The hot air temperature at 60, 70 and 80 degree Celsius,, while the air velocity at 0.5, 1.0 and 1.5 meter per second, from the experiment it was found that the heat flux of the heat exchangers was the best, when using the air velocity at condensed part at 0.5 meter per second, temperature at 80 degree Celsius, thermal effectiveness exhibited 0.29.

4. Conclusions

This paper deals with the heat transfer characteristic of closed-loop oscillating heat pipe with check valves (CLOHP/CV) on fins using Silver nanofluid as working. To check on heat flux and effectiveness needed to focus on evaporator temperature and air velocity. The heat exchanger used Silver nanofluid as working fluid with the filling ratio of 50% by total volume of the tube, evaporator temperature at 60, 70 and 80 degree Celsius, and air velocity at 0.5, 1.0 and 1.5 meter per second, one at time. All heat exchangers used different sizes of radial fin heat was 0.5 centimeter. The CLOHP/CV was made from 24 turns of copper capillary tube (inner diameter: 5 mm) with 2 check valves. From this study can be summarized the heat pipe CLOHP/CV of heat exchangers at temperature at 80 degree Celsius, and air velocity at 0.5 m/s at condenser section of heat pipe, exhibited the maximum heat flux and thermal effectiveness.

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