ISSN 2395-1621

Experimental investigation of Heat pipe Heat exchanger for Heat Recovery System

[#1]Manisha S. Rathod, [#2]Dr.Ajit M. Kate

[1]manisha08rathod@gmail.com
[2]kateajit22@gmail.com
[#1]Mechanical Department, Pune University
Pune
[#2]KJCOEMRPune, India

ABSTRACT

This paper deals with the waste heat recovery using heat pipe heat exchanger. Heat pipe is a device which carries the heat from high temperature region & ejects it to the cold or low temperature region. The advantage of using a heat pipe over other conventional methods is that large quantities of heat can be transported through a small cross-sectional area over a considerable distance with no additional power input to the system. The heat pipe heat exchangers are used in heat recovery applications to cool the incoming fresh air. Two streams of fresh and return air are connected with heat pipe heat exchanger to investigate the thermal performance and effectiveness of heat recovery system. The aim of this project work is to investigate the thermal performance and effectiveness of heat pipe heat exchanger for heat recovery applications by measuring the temperature difference of warm and cold air through the evaporator and condenser side. The hot-air temperature increased from 60 to 90^0C; the heat-transfer rate increased slightly. The velocity increase from 8.5, 10, 16.3, to 18.7 m/s led to a slight decrease in effectiveness. As the hot-air temperature increases from 60 to 90^0C, the effectiveness slightly increased.

***Keywords*— Heat pipe, Heat pipe Heat exchanger, Heat recovery, Thermal Performance.**

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. Introduction

In the light of an ever increasing demand for energy, the need for energy savings has become an important economic consideration. One means of saving energy is to recover a portion of the energy in a warm waste stream and then to use the recovered energy to preheat another colder stream. Heat pipe heat exchanger for heat recovery equipment are aimed for recovering sensible heat and they are recommended for systems in which inlet and return air should not be mixed such as surgery rooms in hospitals and chemical and biological laboratories. The advantage of using heat pipes over conventional methods is that large quantities of heat can be transported through a small cross-sectional area over a considerable distance with no additional power input to the system, (except for the fans to drive the airstreams) together with simplicity of design and ease of manufacture, [1]; less pressure drop of fluid; advanced maintainability; high reliability; simpler structure and smaller volume. Gravity assisted heat pipe, for its special characters of without wicks, has found numerous applications in heat recovery systems in terrene.

HPHXs are suitable for energy recovery in AC systems in tropical areas where the inlet fresh air at high temperature could be pre-cooled before it reaches the cooling coil. A HPHX is a heat exchanger consisting of externally finned tubes filled with a proper refrigerant (i.e. working fluid). There are two heat transfer sections in HPHXs, i.e. the evaporator and the condenser sections for the heat exchange between the two air streams.

Noie-Baghban and Majideian [2] studied the theory, design and construction of heat pipes, especially their use in heat pipe heat exchangers for energy recovery, reduction of air pollution and environmental conservation. Mostafa and Mohamed [3] used heat pipe heat exchanger in heat recovery applications to cool the incoming fresh air in air conditioning applications. Martinez et al. [4] designed a mixed air-energy recovery system, consisting of two heat pipes and indirect evaporative recuperators. Feng Yang et al. studied [5] the feasibility of using heat pipe heat exchangers for heating applying automotive exhaust and the calculation method is developed. Rittidech et al. [6] designed the house casing was to be suitable for the CEOHP. It was found that, as the hot-gas temperature increases from 60 to 80^{0}C, the thermal effectiveness slightly increases. If the working fluid changes from water to R123, the thermal effectiveness slightly increases. The designed CEOHP air-preheater achieves energy thrift. Meena used [7] a CLOHP/CV air-preheater for recovering the waste heat from the drying cycle.Yat H. Yau [8] is recommended that tropical HVAC systems should be installed with heat pipe heat exchangers for dehumidification enhancement.Hagens et al. [9] concluded that a heat pipe equipped heat exchanger is a good alternative for air–air exchangers in process conditions when air–water cooling is impossible, typically in warmer countries. Laubscher and Dobson [10]concluded that the theoretical simulation model can be used to predict the performance of a higher temperature sodium-charged heat pipe heat exchanger, provided suitable boiling and condensation heat transfer coefficients are used. Longo et al [11] compare consistency of the experimental results with a semi-empirical model of the heat exchanger based on heat transfer correlations available in literature.

II. DESIGN & CONSTRUCTION OF HEAT PIPE

The selected range of heat input was within 150-300 W for the single heat pipe. It is necessary to have a heat pipe capable of transferring a minimum of 100 W at the temperature range between5-200^{0}C.

The heat pipe with the following features designed.

Material of Heat Pipe	SS 304 stainless steel.
Working Fluid	Water
Diameter of Heat pipe	25.4 mm
Length of Heat pipe	600 mm
Length of evaporator section	275 mm
Length of condenser section	275 mm
Length of adiabatic section	50 mm
Thickness of pipe	3 mm

Table 1: Specification of heat pipe

After obtaining the above characteristics for the single heat pipe, 40 heat pipes were manufactured. The Heat pipes were manufacture by the process consisted of washing, creating the vacuum, injecting the working fluid and testing of each individual heat pipe.

III.EXPERIMENTAL SETUP

The air to air Heat Pipe Heat Exchanger test rig has been designed and constructed to evaluate the effectiveness and thermal performance of heat pipe heat exchanger, of the air-to-air heat pipe heat exchanger shown in Fig 1.

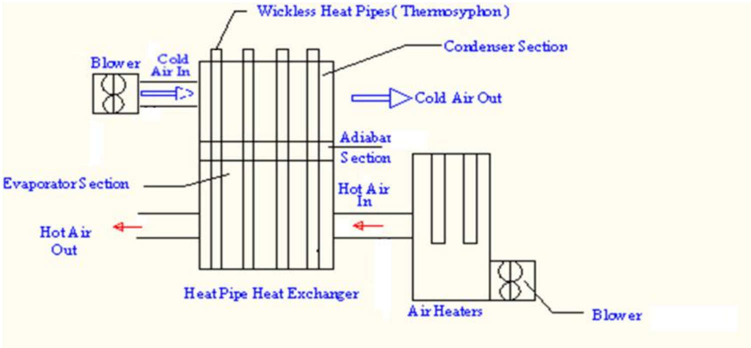

Fig1: Schematic of the heat pipe heat exchanger

A heat exchanger consisting of 40 heat pipes was used in the tests. Heat pipes in staggered equilateral triangle arrangement with dimensions of 940X700X420 mm (LenghthXheightXwidth) were manufactured.

The test rig consists of two blowers at condenser evaporator end having mass flow rate of 0.43m^3/s. The air velocity of cold air was 19 m/s and maintained constant throughout the experimentation. The hot air velocity has been varied from 8.5m/s, 10 m/s, 16 m/s and 18 m/s. The Two PT100 type sensors were installed at evaporator and two were installed at condenser section to measure inlet and outlet temperature of hot and cold stream. The air is heated by using air heaters of capacity 20 KW. The actual experimental test rig is as shown in Fig. 2.

Fig2: Actual experimental test rig

IV.EXPERIMENTAL RESULT & DISCUSSION

A series of tests was performed in order to investigate the characteristics of the heat pipe heat exchanger. The readings were taken by varying mass flow rate of hot air and different hot air temperatures.

The changes evaporator inlet temperatures at various mass flow rates are illustrated in fig 3. It is observed that evaporator inlet temperature increase with decrease in mass flow rate. Also the changes of effectiveness at various inlet temperatures and mass flow rates are illustrated in Fig. 4. It is observed that the effectiveness is increased with increasing the hot air inlet temperature. The effectiveness is more for maximum evaporator inlet temperature and minimum mass flow rate.

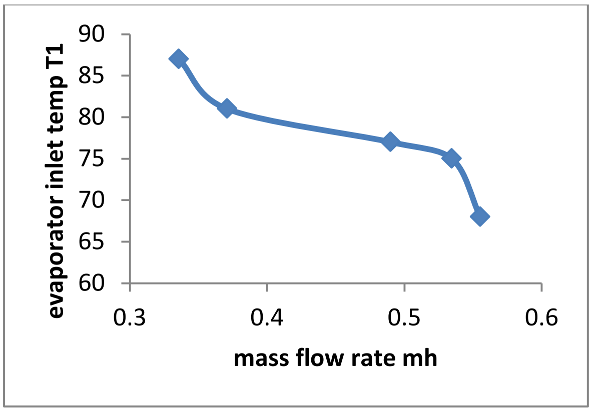

Fig 3: Effect of mass flow rate on evaporator inlet temperature

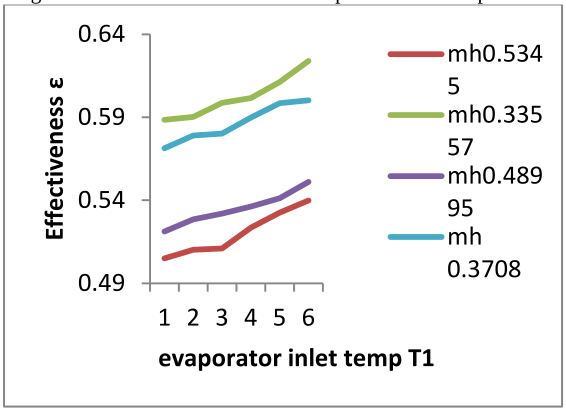

Fig 4: Effect of evaporator inlet temperature on effectiveness

The effects of mass flow rate on the effectiveness of the heat exchanger are indicated in Fig. 5 It is observed that the effectiveness is increased with decreasing the hot air mass flow rate. The effect of change in Reynolds no on heat transfer coefficient is given in fig 6. It is observed that as Reynolds no increases Nusselt No also increases this causes increase in heat transfer coefficient.

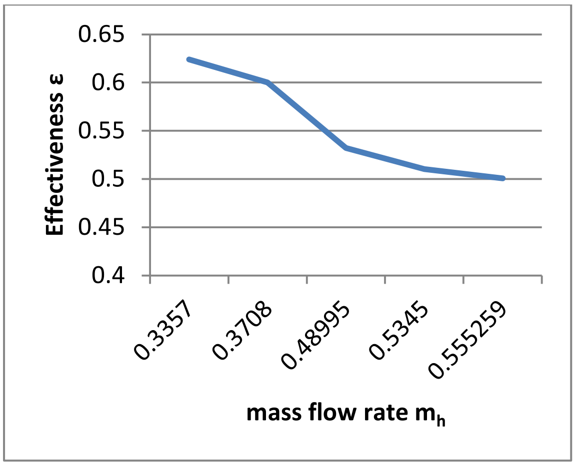

Fig 5: Effect of mass flow rate on effectiveness

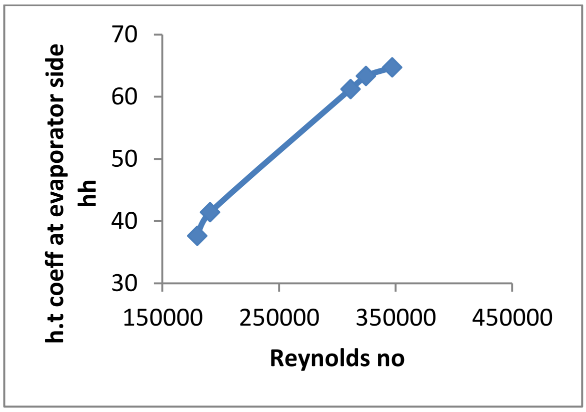

Fig 6:Effect of Reynolds no on heat transfer coefficient at evaporator side

V.CONCLUSION

The experimental study of heat pipe heat exchanger leads to the following conclusions:

1. The heat transfer for both evaporator and condenser sections were increased with increasing the hot air inlet temperature.
2. Decrease of hot air mass flow rate results increase in hot air temperature and effectiveness of heat pipe heat exchanger also increased.
3. Increase of hot air temperature results increase in effectiveness of heat pipe heat exchanger.
4. increase in Reynolds number at evaporator side causes the increase in heat transfer coefficient at evaporator side.

ACKNOWLEDGMENT

Special thanks to Dr. A. M. Kate, Guide, Department ofMechanical Engineering, University of Pune, for his support during critical portions of the project.

REFERENCES

[1] R. Brown et al., Design of the SHARE II monogroov heat pipe, in: Proceedings of the AIAA 26th Thermophysics Conference, Paper No. AIAA 91-1359, 1991.

[2] Noie-Baghban S, Majideian G. Waste heat recovery using heat pipe heat exchanger (HPHE) for surgery rooms in hospitals. Applied Thermal Engineering 2000; 20:1271–82.

[3] Abd El-Baky MA, Mohamed MM. Heat pipe heat exchanger for heat recovery in air conditioning. Applied Thermal Engineering 2007; 27:795–801.

[4] Martinez FJR, Plasencia MAA, Gomez EV, Diez FV, Martin RH. Design and experimental study of mixed energy recovery system, heat pipe and indirect evaporative equipment for air conditioning. Energy and Buildings 2003; 35:1021–30.

[5] Yang F, Yuan X, Lin G. Waste heat recovery using heat pipe heat exchanger for heating automobile using exhaust gas. Applied Thermal Engineering 2003; 23:367–72.

[6] Rittidech S, Dangeton W, Soponronnarit S. Closed-ended oscillating heat pipe (CEOHP) air-preheater for energy thrift in a dryer. Applied Energy 2005; 81:198–208.

[7] Meena P, Rittidech S, Poomsa-ad N. Closed-loop oscillating heat-pipe with check valves (CLOHP/CVs) air-preheater for reducing relative humidity in drying systems. Applied Energy 2007; 84:363–73.

[8] Yat H. Yau, Application of a heat pipe heat exchanger to dehumidification enhancement in a HVAC system for tropical climates—a baseline performance characteristics study, International Journal of Thermal Sciences 46 (2007) 164–171.

[9] H. Hagens, F.L.A. Ganzevles, C.W.M. van der Geld, M.H.M. Grooten, Air heat exchangers with long heat pipes: Experiments and predictions, Applied Thermal Engineering 27 (2007) 2426–2434.

[10] RynoLaubscher, Robert T. Dobson, Theoretical and experimental modelling of a heat pipe heat exchanger for high temperature nuclear reactor technology, Applied Thermal Engineering 61 (2013) 259-267.

[11] Giovanni A. Longo, Giulia Righetti, Claudio Zilio, Fabio Bertolo,Experimental and theoretical analysis of a heat pipe heat exchanger operating with a low global warming potential refrigerant