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EFFECT OF TiO_2 NANO PARTICLE IN WASTE HEAT RECOVERY SYSTEM USING HEAT PIPES

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Abstract

In recent years, there has been a substantial increase in energy demand due to industrialization and development. Energy can be optimized through waste heat recovery system. In the present work a set of heat pipes with aluminium fins is used to connect the fresh air and return air from an air conditioned room thereby recovering the waste heat. The working fluids used were R134a and R134a along with TiO_2 Nano particle. The results show that TiO_2 nano particle with R134a enhances the overall effectiveness.

Index Terms: *Heat pipe heat exchanger, waste heat recovery system, HVAC*

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1. INTRODUCTION

The increase in demand of energy has forced the researchers to find an alternate source and also to improve the efficiency of the existing system. To improve the efficiency of an existing system waste heat recovery system is ardently used. It is seen that the maximum quantum of energy produced in the world is utilized for space heating, ventilation, and air conditioning system [HVAC]. In a HVAC system heat pipe heat exchanger is used as heat recovery system. Heat pipe heat exchanger is more effective, with less maintenance and lower in cost than any other types of exchangers.

Y.H.Yau et.al.,(2010)[1] Investigated on heat recovery system, his work was focused on the application of heat pipe heat exchanger. He had strongly recommended the heat pipe heat exchanger for energy saving and dehumidification application. In the heat pipe heat recovery system using R11 as a working fluid, Mostafa Abdul-Balky et.al., (2007)[2] found that the impact of flow rate of air and temperature of fresh air were important parameters to increase the effectiveness. While Feng yang et.al., (2003)[3] did an experimental investigation in a heat pipe heat exchanger to recover the heat from a automobile exhaust. It was found that when there was an increase in exhaust temperature the performance also increased.

In the present scenario the major investigations are focused on improving the heat pipe performance. The predominant factor influencing the performance is the selection of working fluid. Existing literature shows that working fluid along with nano particle improves the performance. Hence, in this study the effect of Tio_2 nano particle along with R134a as a working fluid for waste heat recovery system is used. The experimentation was done for various fresh air temperatures. The results were compared with R134a.

2. NANO FLUID

In this experiment TiO_2 of 45 nm in size was dispersed in DI water (base fluid) and sonicated for 12 hrs using ultrasonic homogenizer at the concentration of 100 mg/lit. The filling ratio was 40% in the evaporator section. The prepared Tio_2 nano fluid was mixed with the working fluid R134a while charging in the ratio of 1:10.

3. EXPERIMENTAL SETUP

The experimental setup containing two air ducts of 0.4 x 0.4 m^2 cross section area were connected by a finned tube heat pipe heat exchanger. The heat exchanger consists of 68 copper tubes having a diameter of 10 mm arranged in 4 rows in a zig-zag manner. The heat pipes with a wick of 6 mm diameter were installed in the galvanized steel duct having a thickness of 1 mm and the heat pipes were surrounded by fins of thickness 0.5 mm. The evaporator section is heated with the help of electrical coil heater. The power input is varied with the help of an autotransformer. The temperature distribution at the wall of heat pipes and surface of fins were sensed with the help of T type thermocouple. Three of them attached to evaporator, three on condenser side and five attached to the adiabatic section and air ducts. All these thermocouples were connected to the temperature indicator. The velocity of air for both condenser and evaporator sections were measured using vane type anemometer.

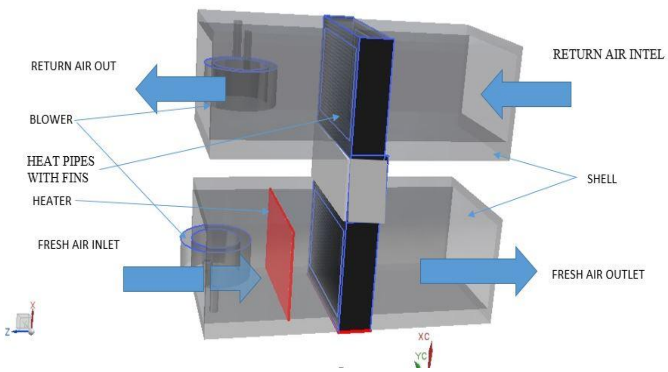

Fig-1: Experimental setup

3.1 Test Procedure

The study was to find out the enhancement of effectiveness in the heat pipe heat exchanger by waste heat recovery system. The flow rate of air was controlled by blowers. The fresh air temperature was varied using electrical heating coil by adjusting the autotransformer while the return air temperature was maintained as a constant.

The heat rejected from the air stream in the evaporator section can be calculated as

$$Q = \dot{m}_O C_P (T_{O.i} - T_{O.o}).$$

The effectiveness of heat pipe heat exchanger at evaporator side is represented as,

$$\xi = \frac{h_{O.i} - h_{O.o}}{h_{O.i} - h_M}.$$

4. RESULT AND DISCUSSION

Fig [2] shows the impact of variation in fresh air inlet temperature to the return cool air. If temperature of fresh air increases, the return air (condenser side) outlet temperature also increased. The temperature between 32°C to 36°C increases the condensation for R134a alone. In case of TiO_2 mixed with R134a it is noted that the increase in condensation is continuous with the increase of fresh air temperature. It also indicates that there exists a considerable amount of reduction in thermal resistance for condensation while adding TiO_2 nano particle.

Fig[3] shows the relation between fresh air inlet and outlet temperatures is explained using (evaporator section). Even though R134a is having a high rate of heat transfer but the variation is not uniform. In the case of TiO_2 nano particle mixed working fluid, the temperature increases continuously with the increase of fresh air inlet temperature.

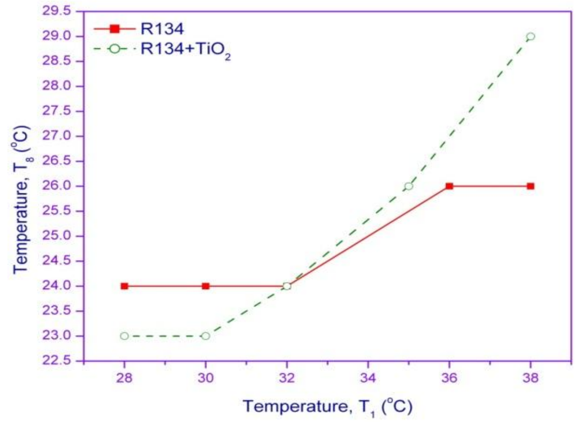

Fig-2: Fresh air inlet temperature Vs Return air outlet temperature

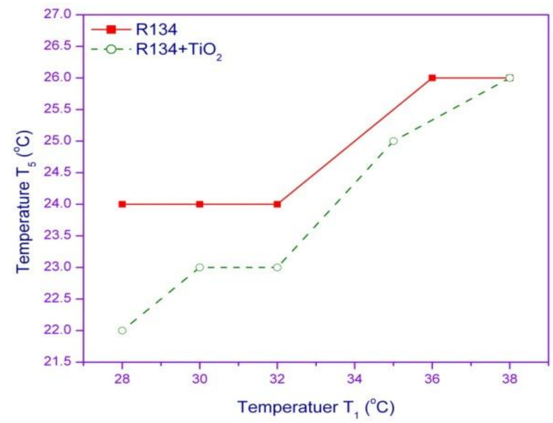

Fig-3: Fresh air inlet temperature Vs Fresh air outlet temperature

The variation in return air inlet temperature is not much while comparing the Refrigerant R134a and R134a with TiO_2 as shown in fig (4).

The overall effectiveness of heat pipe is increased while using TiO_2 nano particle. Fig(5) shows the effectiveness for two working fluid. From the fig 5 it is clear that, the increased effectiveness is obtained while using TiO_2 nano particle mixture. In case of R134a, the maximum effectiveness is 0.79 at maximum temperature while in case of Tio_2 with R134a, the maximum effectiveness is 0.91. This is due to the high amount of heat rejection in condenser section resulted by nano particle and the entire experiment processes were run smoothly.

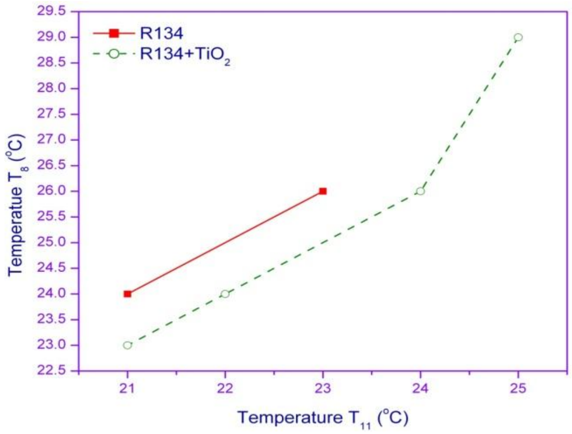

Fig-4: Return air inlet temperature Vs Return air outlet temperature

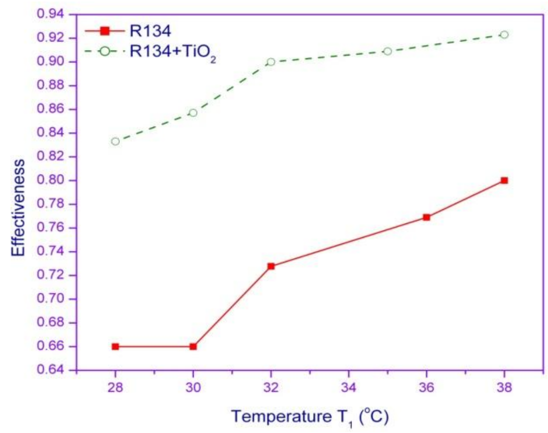

Fig-5: Fresh air inlet temperature Vs Effectiveness

5. CONCLUSION

The experimental study of heat pipe heat exchanger for cooling fresh air with return air conditioning leads the following conclusion

The addition of TiO_2 nano particle with R134a enriches the fresh air temperature when compared to R134a

Increase in the fresh air temperature will reduce the work done of the air conditioning system by 15%

The maximum effectiveness is obtained at maximum fresh air temperature while using TiO_2 nano particle along with R134a.

NOMENCLATURE

Cp	specific heat (J kg_1 K_1)
Q	heat transfer rate (W)
R	gas constant (J kg_1 K_1)
r	radius of heat pipe (m)
T	temperature (°C)
T_{max}	temperature of inlet fresh air (°C)
T_{min}	temperature of return cold air (°C)
U	overall heat transfer coefficient (W/ m^2 K)
e	effectiveness
c	specific heat ratio for gas Cp/CV
ρ	density (kg/ m^3)
s	surface tension (N m)
x	humidity ratio (kg /kg of dry air)

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BIOGRAPHIES

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