Experimental Investigation of Heat Pump Using R-134a And Nano Refrigerants

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Abstract- *Experimental investigation of Heat Pump performance using Nano-refrigerant is presented in this work. Nano-refrigerant was prepared in current work by mixing 50 nanometers diameter of copper oxide CuO nanoparticles with Polyolester lubrication oil and added to the compressor of the refrigeration system to be mixed with pure refrigerant R-134a during its circulation through refrigeration system. Three concentrations (0.15%, 0.30%, and 0.45%) of CuO-R134 a Nano-refrigerant are used to study the performance of the refrigeration system test rig and to investigate the effect of using Nano-refrigerant as a working fluid compared with pure refrigerant R-134a. The results showed that, the increasing in concentration of CuO nanoparticles in the Nano-refrigerant will significantly enhance the performance of the refrigeration system, as adding nanoparticles will increase the thermal conductivity, heat transfer and improve the thermo-physical properties of Nano-refrigerant.*

Keywords- Nano-refrigerant, Nano fluid, Nanoparticles, Actual Coefficient of performance of Heat pump using R-134 a and using CuO with R-134 a.

I. INTRODUCTION

American society of refrigeration engineers defines the refrigeration as science of providing and maintaining temperature below of above the surrounding temperature.

A heat pump is a machine or device that takes heat from one location (the 'source') at a lower temperature to another location (the 'sink' or 'heat sink') at a higher temperature using mechanical work or a high-temperature heat source.

Heat pumps have been used in a number of different areas for years. The first heat pump is said to have been built in 1856 and the first ground source heat pump in 1948. However, it is only within the last few years that popularity has soared, with heat pumps being used for heating both domestic and commercial properties. Based on similar technology to air conditioners and freezers, heat pumps use the heat found in air, water or the ground and compress it using electricity. Heat pumps provide heat energy from a variety of sources, depending on the model, to a heat sink. In order to work, they are required to shift thermal energy in the opposite direction to natural order. In other words, they take heat from a cooler environment and release it into a warmer on.

SCHEMATIC LAYOUT:

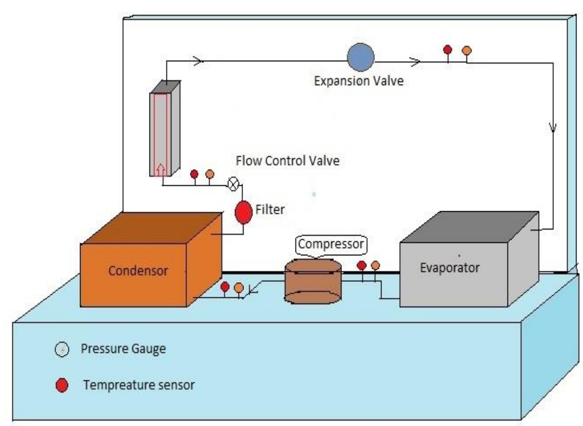

Fig.1-Schematic Diagram of Experimental Set Up

II. APPARATUS

1. **Compressor: -** The low pressure and temperature vapour from evaporator is sucked into compressor and compressed it to high pressure and temperature vapour and send it to condenser. **This compressor is charged with R134a.**
2. **Condenser: -** The high pressure and temperature vapour from compressor is sucked passed through the condenser where it loses its latent heat to cooling water circulating around the condenser coil and gets condensed to liquid refrigerant at same pressure.
3. **Expansion valve: -** The high pressure liquid refrigerant is made to flow through thermostatic expansion device. In this the Condenser pressure is reduced to evaporator pressure and temperature.
4. **Evaporator: -** The low pressure and temperature liquid refrigerant form expansion device flows through evaporator where it gains heat from surrounding water

and gets evaporated to low temperature gaseous refrigerant.

SAFETY PRECAUTIONS:

- Ensure both tanks are filled with water at atmospheric temperature upto the marked level.
- Both the pump should start before starting the compressor
- HP cut-out: - the compressor will get switch off if condenser pressure will exceeds the 280psi.
- LP cut-out: - the compressor will get switched off if evaporator pressure will lowered below 10psi.
- Do not run the system more than 50 minutes.
- Do not touch any component and tube during the testing.
- The connection and joints are delicate may lead to leakage of refrigerant.
- Tanks must be cleaned periodically and filled with fresh water.

III. PHOTOGRAPH OF EXPERIMENTAL SET UP:

Fig.2 Photograph of Experimental Set Up

IV. TESTING PROCEDURE

Ensure both the tanks are filled with water at atmospheric temperature and then start both the water pump. After few minutes start the compressor. Note the energy meter reading and take the temperature and pressure readings after every 10min. Also take the temperature of water tank after every 10min. The four readings should be taken that is run the setup for 40minutes as after 40 min the system is observed to be steady. After 40minutes put the compressor switch off.After 2minutes of switching compressor off put the motors off.

V. EXPERIMENTALWORK

The experimental work was conducted on Heat Pump Test Rig and the experimental tests are carried out to investigate the performance of the Heat Pump in two cases, at first a pure refrigerant R-134a was used as base line case and at a second case, CuO-R134a Nano-refrigerant was used for performance comparison. The Heat Pump test rig used in current work is consists of, reciprocating compressor, wire and tube air cooled condenser, capillary tube as expansion device , freezing compartment (evaporator) and other accessories as shown in figures (2) and (3). Pressure gauges and thermocouples with readers are at first calibrated and then placed at various locations in the test rig system to measure the pressure and temperature of the refrigerant throughout operation period. The test rig system is at first air evacuated and charged with 200g of refrigerant R-134a and the experimental results including, temperatures, pressures, refrigerant mass flow rate and electrical power consumption are established with measurement time interval during 2 hours test period to be a foundation for system performance comparison. The refrigerant R-134a was then recovered from the Heat Pump system and the system charged with 225g of Nano-refrigerant by adding CuO-lubrication oil suspension to the compressor of the refrigeration system and the tests were conducted under the same operating conditions with three concentrations of Nano-refrigerant, 0.15%, 0.30%, and 0.45% of nanoparticles-R134a.

A) OBSERVATION TABLE NO.1

S.N	Observation	Symbol	Unit	Reading
1	Compressor Discharge Pressure	P_c	Bar	16.513
2	Compressor Suction Pressure	P_c	Bar	2.113
3	Evaporator Inlet Temperature	T_1	^0C	-2.3
4	Evaporation Outlet Temperature	T_2	^0C	-1.7
5	Condenser Inlet Temperature	T_3	^0C	79
6	Condenser Outlet Temperature	T_4	^0C	37
7	Initial Water Temperature in tub	T_i	^0C	31
8	Final water Temperature in tub	T_f	^0C	40
9	Energy meter Initial reading	EM 1	kW-Hr	5.6
10	Energy meter final reading	EM 2	kW-Hr	6.2
11	Duration of trial	t	Min	40
12	Initial Temperature of water	Tw1	^0C	31
13	Final Temperature of water	Tw2	^0C	48

B) Observation Table No.2Using Nano Refrigerant (0.45 % concentration).:-

S.N	Observation	Symbol	Unit	Reading
1	Compressor Discharge Pressure	P_c	Bar	16.7
2	Compressor Suction Pressure	P_e	Bar	2.23
3	Evaporator Inlet Temperature	T_1	°C	-3.1
4	Evaporation Outlet Temperature	T_2	°C	-1.9
5	Condenser Inlet Temperature	T_3	°C	83
6	Condenser Outlet Temperature	T_4	°C	38
7	Initial Water Temperature in tub	T_i	°C	33
8	Final water Temperature in tub	T_f	°C	50
9	Energy meter Initial reading	EM 1	kW-Hr	6.2
10	Energy meter final reading	EM 2	kW-Hr	6.8
11	Duration of trial	t	Min	38
12	Initial Temperature of water	Tw1	°C	32
13	Final Temperature of water	Tw2	°C	55

VI. CALCULATIONS

A) Formulea

1. $(COP)_{actual} = \frac{HeatingEffect of water}{Powerconsumed}$

- Heating Effect (kW):

$$= \frac{40*4.187*(40-31)water(kJ)}{40*60} = 1.1863 \text{ Kw}$$

Where, $(\Delta T)_{water}$ = Change in temperature of water in tub.

$C_{p=}$ 4.187 kJ/Kg

m= mass of water in tub

= 40litres

- Power consumed (kW)

$$= \frac{(Finalenergymeterreading - Initialenergymeterreading)kW-Hr}{Durationoftrial(Hr)}$$

= 6.2-5.6/40/60 = 0.8995 Kw

$(COP)_{actual} = \frac{1.1863}{0.8995}$ = 1.3188

2. $(COP)_{theoretical} \frac{hci-hco}{hci-heo}$ = 590-452/640-590 = 2.76

Where, h_{ci}=Enthalpy at condenser inlet

h_{co}=Enthalpy at condenser outlet

h_{eo}=Enthalpy at evaporator outlet

1.$(COP)_{carnot} \frac{Th}{Th-Tl}$ = (59.23+ 273)/ 59.273-8.67 = 6.57

Where, $T_{h=}$ Saturation Temperature at Condenser Pressure

T_l= Saturation Temperature at Evaporator Pressure

B) Actual Calculations (Without Nano Refrigerant):

(0.45 % concentration).

** In this R-134 a refrigerant is used along with CuOnano fluid

1. $(COP)_{actua=l} \frac{HeatingEffectwater}{Powerconsumed}$ =

- Heating Effect (kW):

$$= \frac{40*4.187*(55-32)}{38*60} = 1.6894 \text{kw}$$

Where, $(\Delta T)_{water}$ = Change in temperature of water in tub.

$C_{p=}$ 4.187 kJ/Kg

m= mass of water in tub

= 40 litres

- Power consumed (kW)

$$= \frac{(Finalenergymeterreading - Initialenergymeterreading)kW-Hr}{Durationoftrial\epsilon(Hr)}$$

= 6.8-6.2/45/60 = 0.8 Kw

$(COP)_{actual=} \frac{1.6894}{0.8}$ = 2.1118

VII. GRAPH

In this graph of COP verses Concentration of CuO is plotted.

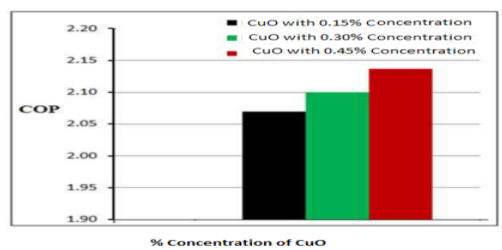

Fig. 3 Graph of COP Verses % Concentration OfCuO

VIII. RESULT AND CONCLUSION

i) There is enhancement in Actual COP of system from 1.32 to 2.1118 for various concentrations of nanofluid CuO.

ii) Three concentrations of CuO-R134a Nano-refrigerant are used to study the performance of the Heat Pump and to investigate the effect of using Nano-refrigerant as a working fluid compared with pure refrigerant R-134a. Concentration percentage (0.45%) of the Nano-refrigerant has reflected higher performance for the refrigeration system compared with other concentrations (0.3% and 0.45%). It can be concluded from the results, that the increasing in concentration of CuO nanoparticles in the Nano-refrigerant will significantly enhance the performance of the refrigeration system, as adding nanoparticles will increase the thermal conductivity, heat transfer and improve the thermo-physical properties of Nano-refrigerant. Investigation of performance parameters for refrigeration system using Nano-refrigerant compared with that for pure refrigerant R-134a showed that, Nano-refrigerant was reflected higher performance in range of 10% increase in COP and 30 % increase in value of Heating effect and 5% reduction in power consumption for refrigeration system, so it can be used efficiently and feasibly in the refrigeration systems.

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