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Experimental Thermal Performance Comparison in the condenser of Heat Pump System using R22 and R134a Refrigerants"

S. Yogendra Kumar[1], H. B. Bhaskar[2], M G Basavaraju[3], N Lohith[4]

[1] Research scholar, Department of Mechanical Engineering, SSAHE, Tumakuru – 572105, Karnataka, India.
[2] Associate Professor, Department of Mechanical Engineering, Sri Siddhartha Institute of Technology, Tumakuru - 572105, Karnataka, India.
[3] Senior Scale Lecturer, Department of Mechanical Engineering (MTT), Government Polytechnic, Chamarajnagara – 570007, Karnataka, India.
[4] Research scholar, Department of Mechanical Engineering, Sri Siddhartha Institute of Technology, Tumakuru - 572105, Karnataka, India.
[1]yogendrakumars1984@gmail.com, [2]bhaskarhb@ssit.edu.in, [3]mahesh7272@gmail.com, [4]lohithn@ssit.edu
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A B S T R A C T

Heat pumps are among the most promising technologies to reduce global warming emissions and to more rationally use energy. The full exploitation of the potential of heat pumps is used more rationally for energy conversion with environmental-friendly refrigerants and higher Coefficient of Performance (COP). It requires further technological progress with modification in the condenser. Heat pumps often provide efficient solutions for heating the water. Although there is a gap in improving the efficiency of the heat pump, in many industrial applications much larger energy savings can be achieved by improving the design and by using different refrigerants. This investigation deals with the standardization of Heat pump and performance analysis of refrigerants for the heating of water in the condenser and to study the COP of Refrigerant, heat transfer rate and Log Mean Temperature Difference (LMTD). The study was performed in a heat pump that includes basic refrigeration elements and the counter flow heat exchanging method is used in the condenser to heat the water from the refrigerant. The analysis performed by using R22 and R134a are Refrigerants which are most used. The experimental results indicate that the efficiency of R134a is much better than R22. The performance of the designed heat pump was evaluated and the value of the Coefficient of Performance indicated that significant energy savings could be realized.

Keywords: Heat pump, Refrigerants, COP, LMTD

1. INTRODUCTION

A Heat Pump is an electrical device that extracts heat from one place and transfers it to another. Refrigerators and air conditioners are types of heat pumps. Heat pumps transfer heat by circulating a substance called a refrigerant through a cycle of alternating evaporation and condensation. A compressor pumps the refrigerant between two heat exchanger coils. In one coil, the refrigerant evaporates at low pressure and absorbs heat from its surroundings. The refrigerant is then compressed and circulated to the other coil, where it condenses at high pressure. At this point, it releases the heat, which is absorbed earlier in the cycle.

1.1 Basic Heat Pump Cycle

An energy-efficient heat pump can give you a way to heat and cool your home and reduce your energy costs. It can provide year-round climate control for your home by supplying heat in the winter and cooling in the summer. Some types can also provide supplementary hot water heating [1,2,3].

2. EXPERIMENTAL SET-UP

2.1 Heat Pump Description

The following are the heat Pump Components,

1. Refrigerant, 2. Reversing Valve, 3. Coil, 4. Evaporator, 5. Compressor 6. Condenser 7. Expansion

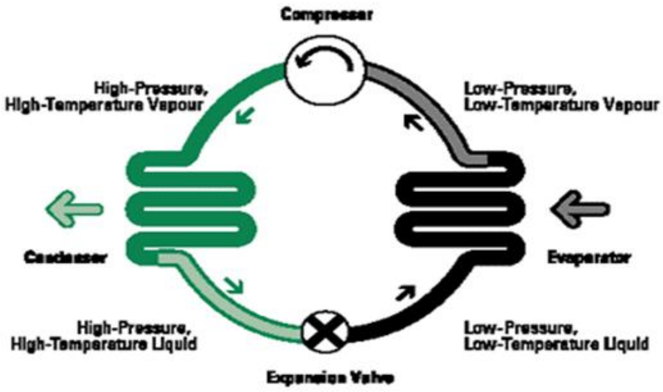


Fig.1. Basic Heat Pump Cycle

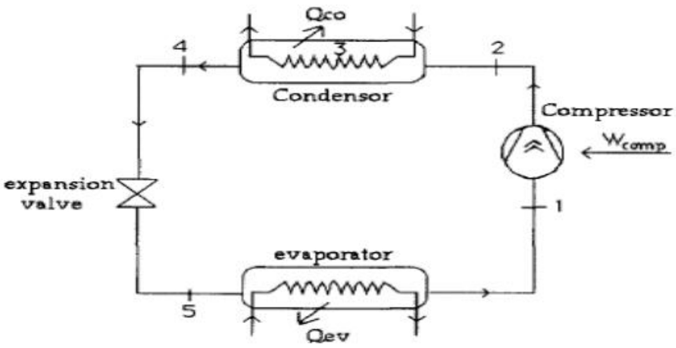


Fig 2: Schematic diagram of Heat pump

Fig.3: Experimental Set up of Heat pump

2.1.1 Refrigerant

The last decade has seen radical changes in the selection and use of refrigerants, mainly in response to the environmental issues of 'holes in the ozone layer' and 'global warming or greenhouse effect'. Previously there had not been much discussion about the choice of refrigerant, as most applications could be met by the well-known and well-tested fluids, R11, R12, R22, R134a R502 and ammonia (R717) [4,5]. The only one of these fluids to be considered environmentally friendly today is ammonia, but it is not readily suited to commercial or air-conditioning refrigeration applications because of its toxicity, flammability and attack by copper. This chapter is about the new refrigerants and the new attitude needed in design, maintenance and servicing of refrigeration equipment.

Reversing valve to the compressor, the accumulator collects any excess liquid that didn't vaporize into a gas. Not all heat pumps, however, have an accumulator.

2.2 Refrigeration Cycle

A simple stylized diagram of the refrigeration cycle:

1) Condensing coil, 2) Expansion Valve, 3) Evaporator Coil, 4) Compressor.

In the refrigeration cycle, a heat pump transfers heat from a lower-temperature heat source into a higher-temperature heat sink. Heat would naturally flow in the opposite direction. This is the most common type of air conditioning. A refrigerator works in much the same way, as it pumps the heat out of the interior and into the room in which it stands.

This cycle takes advantage of the way phase changes work, where latent heat is released at a constant temperature during a liquid/gas phase change, and where varying the pressure of a pure substance also varies its condensation/boiling point.

2.3 Apparatus

The experimental set of apparatus is shown in Figure 3. The system is a heat pump composed of the following main parts: compressor, evaporator, condenser, expansion valve. Miscellaneous equipment is added, including Temperature- and pressure-measuring instruments are attached to the system. Also fitted are the heat source and heat sink units, to supply secondary fluids (water is used in this study) at nearly uniform temperatures.

The compressor is of capacity 1.5kWh to compress the refrigerant to temperature around 90-95°C (363-368K) and a pressure is ranges from 0.1378MPa to 2.0684MPa. High temperature and high pressure compressed refrigerant is then passed to condenser.

The condenser is heat exchanger where heat is exchanging between hot refrigerant and cold water which works on counter flow basis, it is shell and tube heat exchanger cold fluid (water) flows on shell side and hot fluid (refrigerant) inside the tube. the Condenser having the shell diameter of 220mm, length of 375mm and tube diameter of 8mm [6,10]. Water enters the condenser at around room temperature and leaves at the temperature of 50-55°C.the refrigerant enters at the temperature of 90-95°C and leaves at the temperature of 50°C.

3. Equations

The following equations were used to calculate different parameters to analyze the performance of the refrigerants R134a and R22.

3.1 Coefficient of Performance (COP)

COP = T2/(T2-T1) -- (1)

3.2 LMTD (Log Mean Temperature Difference):

LMTD = (θ1- θ2)/ln(θ1/ θ2) --- (2)

3.3 Rate of heat exchanged in a heat exchanger (q):

Q=MwCpw(Two-Twi) --- (3)

3. RESULTS AND DISCUSSIONS

The Table1 and Table 2 above were plotted for the various temperatures to calculate COP of R22 and R134a.

Table 1: Experimental readings for refrigerant R22

Trial no.	T_1	T_2	T_3	T_4	COP
1	07	86	44	24	4.54
2	08	87	46	22	4.55
3	09	88	47	21	4.56
4	11	90	48	20	4.59

Table 2: Experimental readings for refrigerant R134a

Trial no	T_1	T_2	T_3	T_4	COP
1	06	81	42	24	4.72
2	07	82	43	23	4.73
3	07	83	44	22	4.75
4	09	84	44	22	4.76

T1= Compressor inlet temperature

T2= Compressor outlet temperature

T3= Condenser outlet temperature

T4= Expansion valve outlet temperature

Twi= Water inlet temperature to Condenser

Two= Water outlet temperature from Condenser

COP= Coefficient of Performance

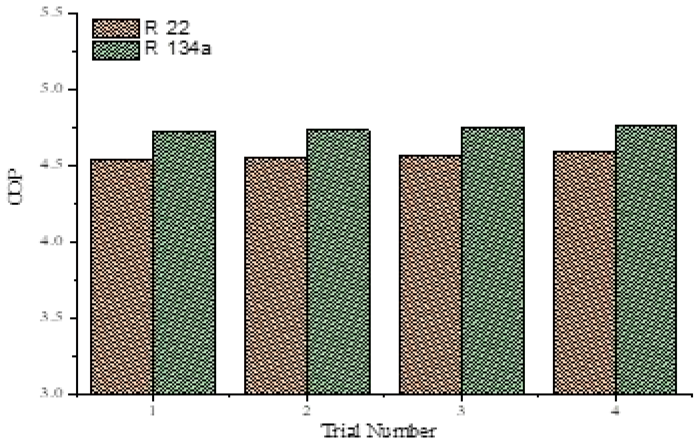


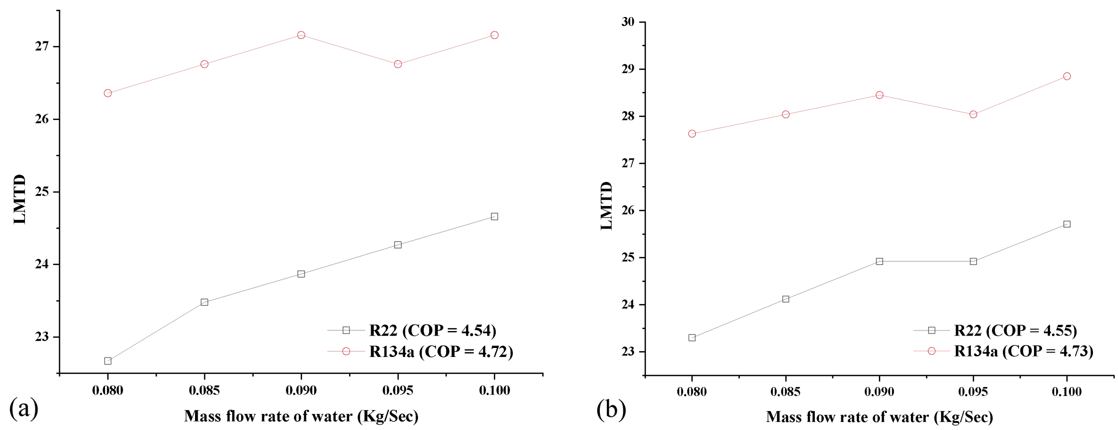
Fig 4. COP for R22 and R 134a

From the Fig 4 we can observe that R134a has more COP than R22 and within the limit.

Table 3: LMTD values of R22 and R134a for 4 trials

LMTD R22				**LMTD R134A**			
TRIAL 1	**TRIAL 2**	**TRIAL 3**	**TRIAL 4**	**TRIAL 1**	**TRIAL 2**	**TRIAL 3**	**TRIAL 4**
22.67	23.3	24.33	24.93	26.36	27.63	27.82	28.42
23.48	24.12	25.15	25.77	26.76	28.04	28.24	28.85
23.87	24.92	25.56	26.19	27.16	28.45	29.07	29.69
24.27	24.92	25.96	26.6	26.76	28.04	28.66	30.1
24.66	25.71	26.36	27.41	27.16	28.85	29.48	30.52

The Table 3 is plotted for various trails and LMTD is calculated by using eqn (2) and plots same are drawn.



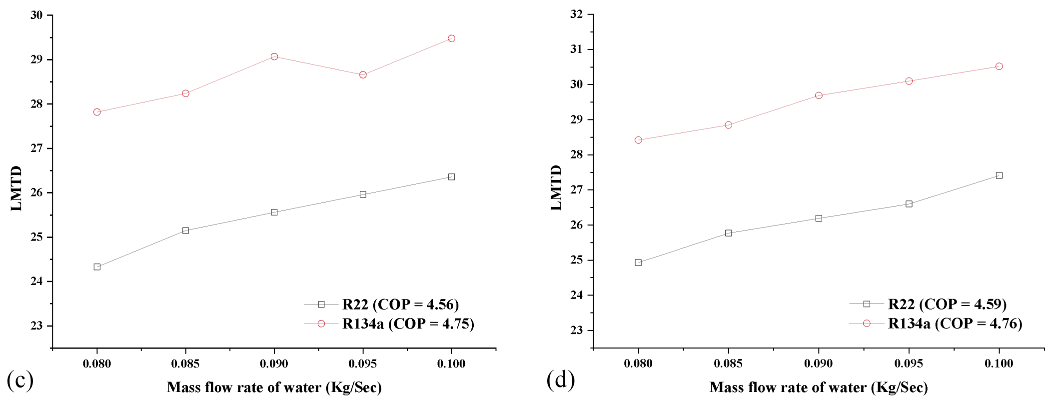


Fig.5 (a, b, c, d). LMTD of R22 and R134a for various mass flow rates

Table 4: Rate of Heat Transfer values of R22 and R134a for 4 trials

R22				R134A			
TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4
7.72	8.06	8.73	9.07	8.4	8.73	9.07	9.40
7.85	8.21	8.56	9.28	8.56	8.92	9.29	9.64
7.93	8.31	9.07	9.45	8.69	9.07	9.45	9.82
8.38	8.77	9.17	9.57	8.77	9.11	9.58	9.97
8.40	8.82	9.24	9.66	8.82	9.24	9.66	10.08

The Table 4 is plotted for various trails and rate of heat transfer in kW is calculated by using eqn (3) and plots same are drawn.

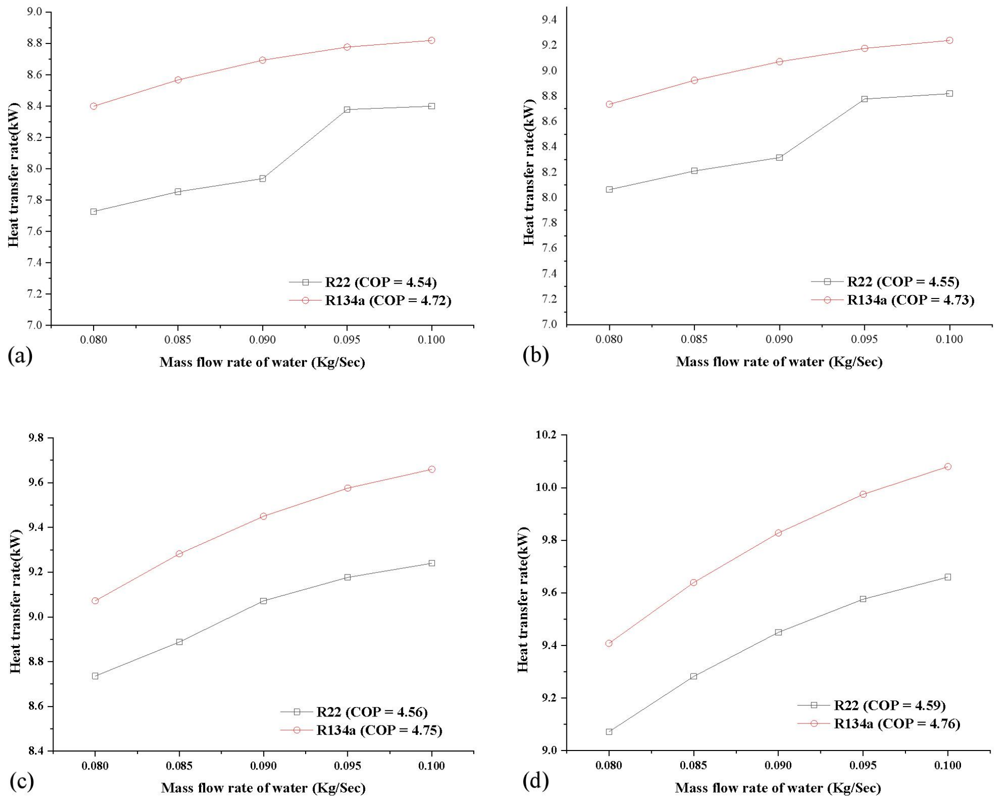


Fig.6 (a, b, c, d). Heat Transfer rate of R22 and R134a for various mass flow rates

From the Figures 5 (a, b, c, d) we can observe that R134a is showing better LMTD than R22 and from Figures 6 (a, b, c, d) Rate of Heat transfer is better in R134A over R22.

4. CONCLUSIONS

In the present investigation, R-22 and R134a refrigerants were used in the model vapor compression heat pump systems for an experimental analysis and R134a found to be effective and efficient alternative to R-22 in heating systems. R134a performance characteristics shows high efficiency, and it is reduced environmental impact than compared to R22.

In this Performance comparisons were primarily made between R134a and R-22(HCFC-22) at equal capacity and performance data summarizes R134a is better COP, high Heat Transfer Rate and LMTD which is use full for higher efficiency than compared to R22.

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