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Experimental Investigation of R152a/R22 Mixture in an Air Conditioning System

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Abstract: ***In domestic air conditioning system the most widely used refrigerant is R22 has a high Global Warming Potential (GWP) of 1700 and a ozone depletion potential (ODP) of 0.05.Hence a new solution for this refrigerant is to be identified. R152a is identified as an alternative to R12 and R22 refrigerants. In this paper an experimental investigation was made to reduce the usage of R22 with the Hydrocarbon Refrigerant mixtures (HCM) of R22 and R152a refrigerants in the ratio of 30:70, 50:50, and 70:30 by mass. Experiments were conducted by continuous running tests under an ambient temperature of 32°C. The overall performance of the system proved that the HCM could be a long term substitute for R22 (chlorodifluoromethane)***

Keywords: Air conditioning, Refrigerant Mixture, Discharge Pressure, COP

1. Introduction

The Refrigerant R22 is a single hydrochloroflurocarbon or HCFC compound, as per ASHRAE classifications are widely used in refrigeration and air conditioning systems. Due to high Ozone Layer Depleting Potential (ODP) and Global Warming Potential (GWP), R22 cannot be used in air conditioning system for long run. The concept of alternative refrigerant comes into picture. Investigating the alternatives, R22 has got 0.05 ODP whereas it is found to be not easily miscible with the conventional mineral oil used as lubricant in air conditioners [1]. The substitute POE oil is highly hygroscopic. The miscibility problem can be overcome by adding suitable quantity of hydrocarbon additives [1,2]. Usage of R22 consumes more power up to 10-15% [3]. The COP of the system was also found to be 3% less than the system with R22 refrigerant [4]. Hydrocarbon refrigerants also have got the problem of flammability [5]. R404a was investigated and compared with the results of R22 and found to be feasible [6]. Hydrocarbon mixture of R290/R600a as an alternative to R22 in a domestic air conditioner was experimented and found to give an improved higher COP of 3.25-3.6% [7].
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2. Theory of Refrigeration and Air Conditioning

Refrigeration may be defined as the process to achieve and keep an enclosed space at a temperature lower than its surrounding temperature. This is done by continuous extraction of heat from the enclosed space whereas the temperature is below than that of the surrounding temperature. Generally air conditioning systems can be classified in 3 main cycle systems which are vapor Compression air conditioning system, vapor absorption air conditioning system, and gas cycle air conditioning system. However the vapor compression air conditioning system is the most widely used in the refrigeration and air conditioning process. It is adequate for most conditioning applications. The ordinary vapor compression air conditioning systems are simple, inexpensive, reliable and practically maintenance free. Most of the domestic air conditioners today are running based on the vapor compression air conditioning system. It is somewhat analogous to a reverse Rankine cycle. The vapor compression air conditioning system contains four main components which are compressor, condenser, expansion device, and evaporator. Compressor is used to compress the low pressure and low temperature of refrigerant from the evaporator to high pressure and high temperature. After the compression process the refrigerant is then discharge into condenser. In the condenser, the condensation process requires heat rejection to the surroundings. The refrigerant can be condensed at atmospheric temperature by increasing the refrigerant's pressure and temperature above the atmospheric temperature. After the condensation process, the condensed refrigerant will flow into the expansion device, where the temperature of refrigerant will be dropped lower than the surrounding temperature caused by the reducing pressure inside the expansion device. When the pressure drops, the refrigerant vapor will expand. As the vapor expands, it draws the energy from its surroundings or the medium in contact with it and thus produces refrigeration effect to its surroundings. After this process, the refrigerant is ready to absorb heat from the space to be refrigerated. The heat absorption process is to be done in the evaporator. The heat absorption process is normally being called as evaporation process. The cycle is completed when the refrigerant returns to the suction line of the compressor after the evaporation process. Low temperature refrigeration, at temperatures below 0 C, affects everyday life. It is mostly used for food preservation, such as in the freezer of a air conditioner.

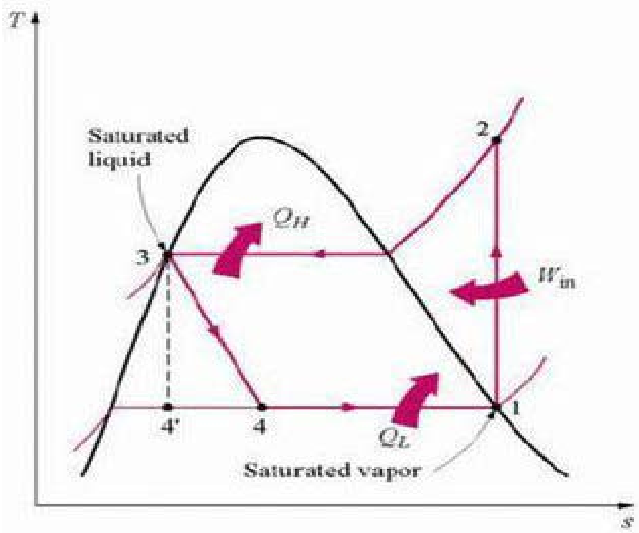

Figure 1: T-S Diagram for the Ideal Vapor Compression Refrigeration Cycle

3. Experimental Setup

A. Components

The experimental consists of compressor, fan cooled condenser, expansion device and an evaporator section. Capillary tube is used as an expansion device. The evaporator is of coil type which is loaded with water. Service ports are provided at the inlet of expansion device and compressor for charging the refrigerant. The mass flow rate is measured with the help of flow meter fitted in the line between expansion device and drier unit. The experimental setup was placed on a platform in a constant room temperature. The ambient temperature was ±1.5°C. The air flow velocity was found to be less than 0.35m/s.

B. Measurement

The temperatures at different parts of the experimental setup are measured using resistance thermocouples. 12 resistance thermocouples were used for the experimentation. The pressure at compressor suction, discharge, condenser outlet and at evaporator outlet is measured with the help of pressure gauges. The power consumption of the system was measures by a digital Watt-hr meter. A digital wattmeter is also connected with the experimental setup. Table1. Summarized the characteristics of the instrumentation.

Table 1: Measurement Equipment

Variable	Device	Range
Temperature	Pt100 PID controller	-50 to 199°C
Pressure	Pressure Gauge	0-10 bar
Power	Digital Watt/Watt-h Meter	5-20A

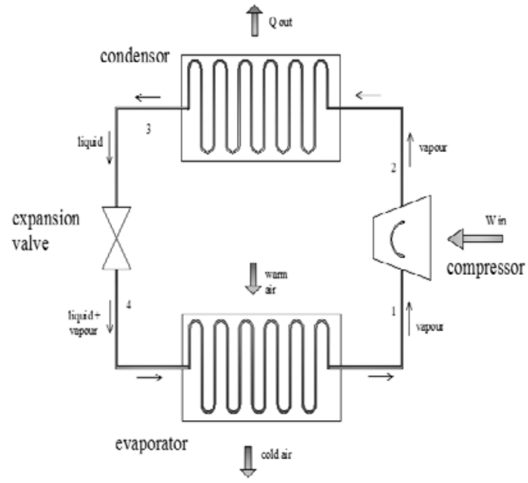

Figure 2. Schematic representation of the experimental setup

C. Leak Proof testing and charging of experimental setup

The fabricated experimental setup was filled with N_2 gas at a pressure of 5 to 7 bar and this pressure was maintained for 5 hrs. Thus the system was ensured for no leakages. The system was evacuated by removing N_2 gas. A vacuum pump was connected to the port provided in the compressor and the system was completely evacuated for the removal of any impurities. This process was carried out for all the trials. The refrigerant R22 and R152a was charged through the charging line to the compressor. Precision electronic balance with accuracy ±1% was used to charge into the system. Every time the system was allowed to stabilize for 10 min.

4. Experimental Procedure

The procedure for the conduction of experiments is as follows:

a) A performance test is made with the system loaded with pure R22. The data is treated as the basis for the comparison with the refrigerant mixtures.
b) Mixture of R152a and R22 by mass in the proportion 30:70, 50:50 and 70:30 was charged in the compressor and the performance tests were conducted.

5. Results and Discussion

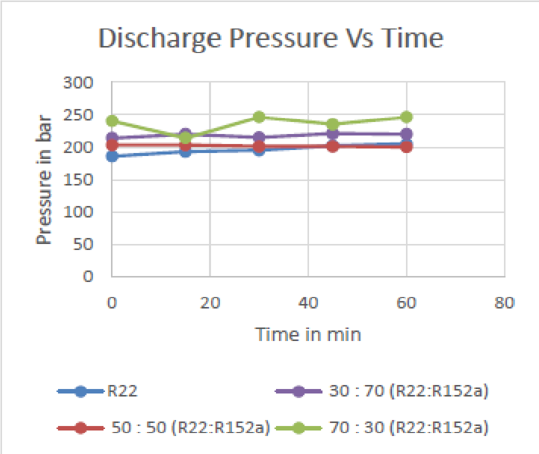

Figure 3: Variation of Discharge Pressure of Compressor with Time

The discharge pressure is found to increase with the mixture of refrigerants and higher discharge pressure was recorded for 0:30 mixtures of R152a and R22.

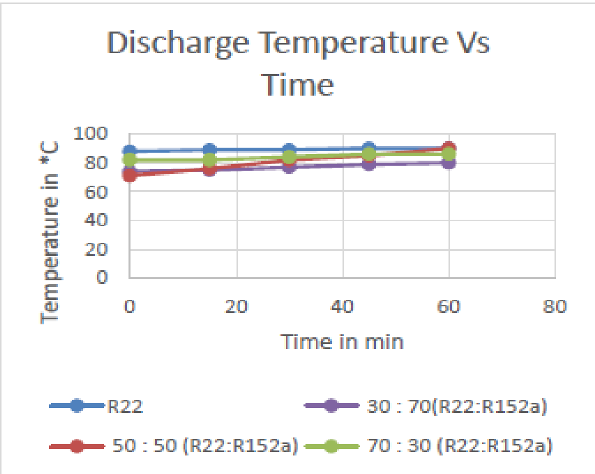

Figure 4: Variation of Discharge Temperature of Compressor with Time

The discharge temperature is found to increase with the mixture of refrigerants and higher discharge temperature was recorded for 70:30 mixtures of R152a and R22.

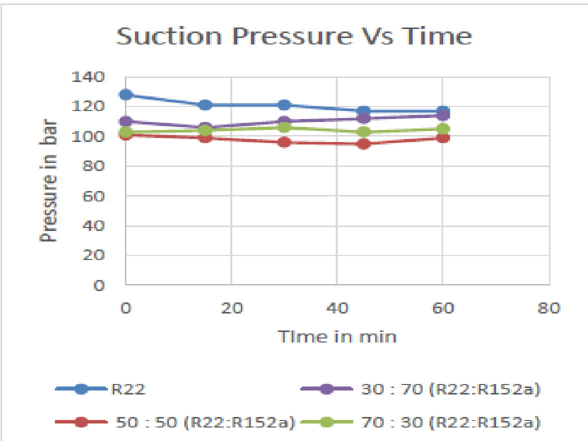

Figure 5: Variation of Suction Pressure of Compressor with Time

The suction pressure is found to decrease with the mixture of refrigerants.

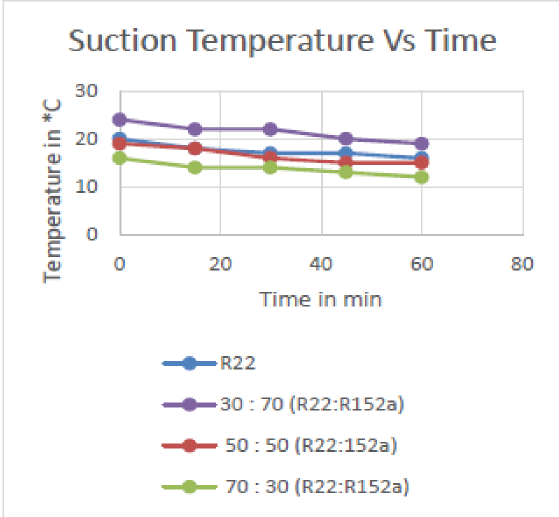

Figure 6: Variation of Suction Temperature of Compressor with Time

The suction temperature is found to decrease with the mixture of refrigerants and lower suction temperature was recorded for 70:30 mixtures of R152a and R22.

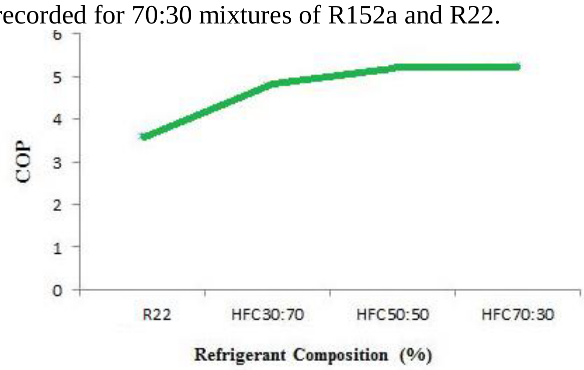

Figure 7: Variation of COP with Refrigerant Mixture

The COP value increases with the increase of refrigerant mixture and the highest value of COP found experimentally was 5.26

6. Conclusion

1) The mixture of R152a and R22 works safely in the system without any system modification.
2) The discharge temperature is found to increase with the mixture of refrigerants and higher discharge temperature was recorded for 70:30 mixtures of R152a and R22
3) The COP value increases and the maximum COP was obtained for 70:30 mixtures of R152a and R22.
4) Highest value of COP found experimentally is 5.26.
5) The obtained results matches with the earlier research trends.[26]

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