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Experimental Performance Analysis of Refrigerant in Refrigeration System

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ABSTRACT:

In Domestic household refrigerators uses R22 refrigerant has a very high Global Warming Potential (GWP) of 1700 and an ozone depletion potential (ODP) of 0.05.Hence a new refrigerant of low GDP is found. R134a & R600a is recognized as an option to R12 and R22 refrigerants. In this paper an experimental analysis has been done to increase the performance of refrigeration system by using R134a & R600a with the same mass. Experiments were carried out by continuous running tests under an ambient temperature of 34°C. The performance of the system predicted that the R600a could be a long term replacement for R22 (chlorodifluoromethane) & R134a (Tetrafluroethane).

Keywords: VCR, Refrigerant R134a,R22, R600a Discharge Pressure, Evaporator Temperature, COP.

INTRODUCTION

The Refrigerant R22 is a sole hydro chloro fluro carbon or HCFC compound, as per ASHRAE categorizations are commonly used in refrigeration and air conditioning systems. Due to high Ozone Layer Depleting Potential (ODP) and Global Warming Potential (GWP) of R22, it cannot be used in Refrigeration system for long time. The resulted the idea of using substitute refrigerant having better eco friendly properties. 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 Refrigeration systems. The substitute POE oil is highly hygroscopic. The miscibility problem can be overcome by adding suitable quantity of hydrocarbon additives .Usage of R22 consumes more power up to 10-15%. The COP of the system was also found to be 3% less than the system with R600a refrigerant. Hydrocarbon refrigerants also have got the problem of flammability. R134a was investigated and compared with the results of R22 and found to be feasible. Hydrocarbon of R134a & R600a as an alternative to R22 in a domestic Refrigerator was experimented and found to give an improved higher COP of 3.25-3.6% along with the less evaporator temperature in lesser time.

THEORY OF REFRIGERATION

Refrigeration system may be defined as the process of extracting heat from the body as per the requirement. In summers, the refrigeration is done in such a way that we get lower

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temperature in an enclosed space compared to outside conditions. This is done by incessant removal of heat from the enclosed space while the temperature is below than that of the surrounding temperature. The vapor compression air conditioning system is the widely accepted in the refrigeration and air conditioning process. It is sufficient for most conditioning applications. The normal vapor compression air conditioning systems are simple, low-priced, consistent and virtually maintenance free. Mainly of the domestic Refrigerators today are operational based on the vapor compression air conditioning system. It is rather equivalent to a reverse Rankine cycle. The vapor compression refrigeration systems have four main components which are compressor, evaporator, condenser and expansion device. Compressor is used to squeeze the small pressure and small temperature of refrigerant from the evaporator to elevated pressure and elevated temperature. After the compression process the refrigerant is then expelled into condenser. In the condenser, the condensation process needs heat elimination to the surroundings. The heat removal process is done in the condenser. It may be condensed at atmospheric temperature by rising the refrigerant's pressure and temperature over 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 within 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 refrigerator.

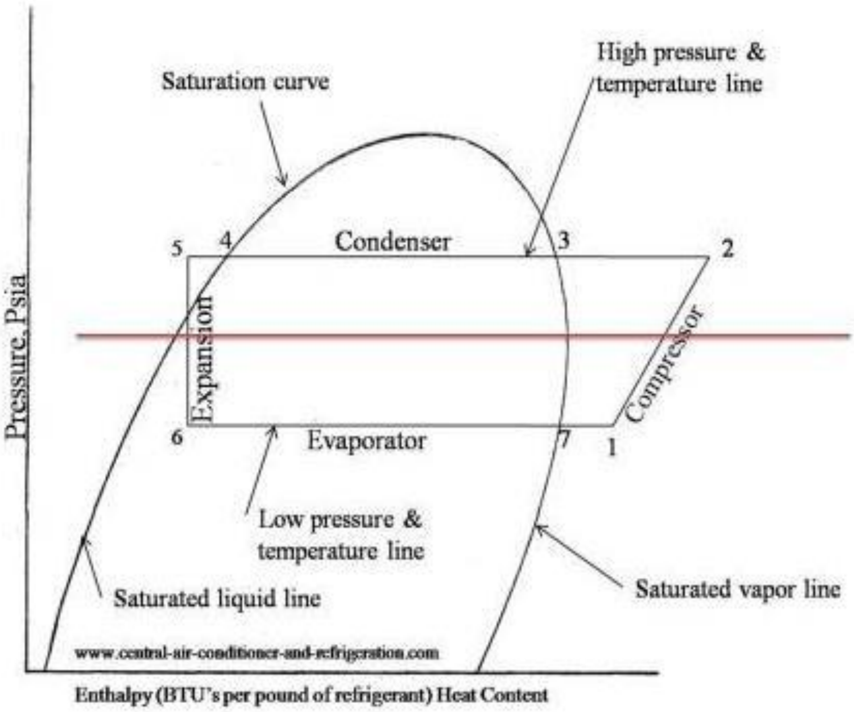

Figure 1: P-h Diagram for the Ideal Vapor Compression Refrigeration Cycle

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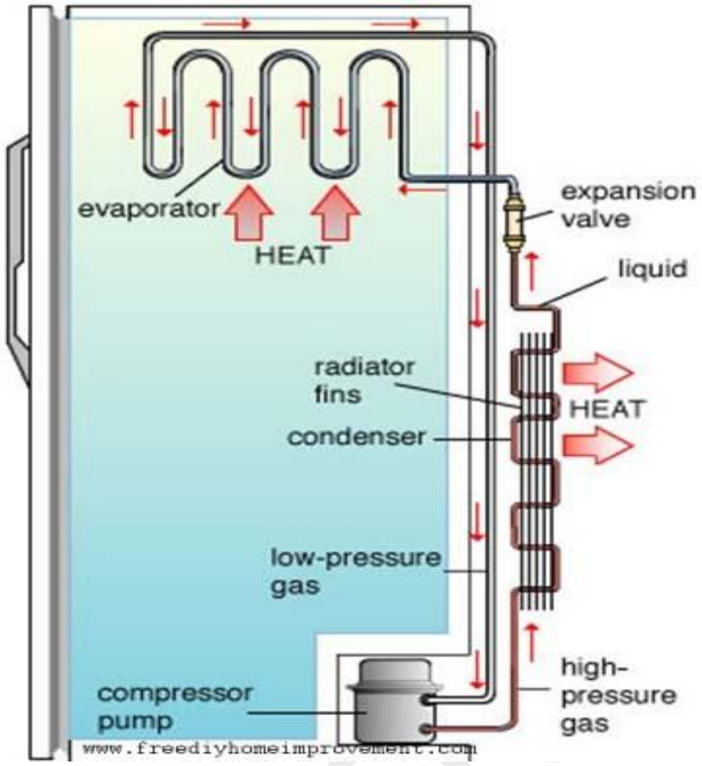

Figure 2: Schematic diagram

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 an ambient temperature of range ±1.5°C. The cooling rate of the water was measured by thermometers in an interval of 10 minutes.

B. Measurement

The temperatures at different parts of the experimental setup are measured using thermometers. Four Alcohol thermometers & a metallic expand thermometer 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.

C. Leak Proof testing and charging of experimental setup

The fabricated experimental setup was filled with refrigerant gas at a discharge pressure of 10 bar and this pressure was maintained for all the refrigerants. Thus the system was ensured for experimentation for different refrigerants with a standard value with no leakages.A vacuum

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pump was connected to the port provided in the compressor and the system was completely evacuated for the removal of any impurities before filling the refrigerants. This process was carried out for all the trials. Precision electronic balance with accuracy ±1% was used to charge into the system. Every time the system was allowed to stabilize for 10 min.

Varible	Device	Range
Temperature	**Thermometer**	**0 to 100^{0}C**
Pressure	Pressure Gauge	0-20 Bar
Power	Digital Watt Meter	5-20A
Refrigerant Flow Rate	Rotameter	0 -50 LPH

EXPERIMENTAL PROCEDURE

The procedure for the conduction of experiments is as follows:

a) A performance test is made with the system loaded with various refrigerant such as R22, R134a & R600a. The data is treated as the basis for the comparison with the refrigerant mixtures. The Refrigerant by mass in the system can be adjusted by the constant level of rotameter charged in the compressor and the performance tests were conducted.

RESULTS AND DISCUSSION

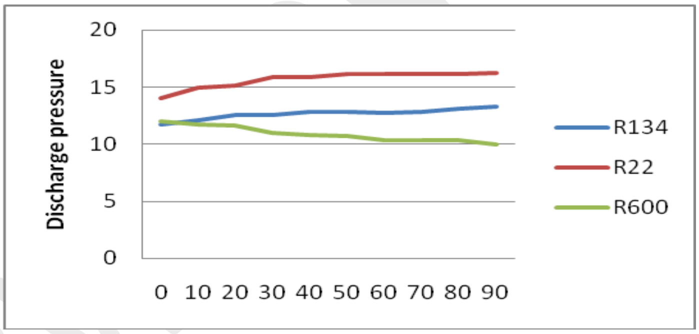

Figure 3: Variation of Discharge Pressure of Compressor with Time

The discharge pressure is found to increase in R22 refrigerant as compared to the R134 a & R600a refrigerants and higher discharge pressure was recorded of 15 bar for R22 only. Whereas, In case of R600a the discharge pressure is gradually decreases.

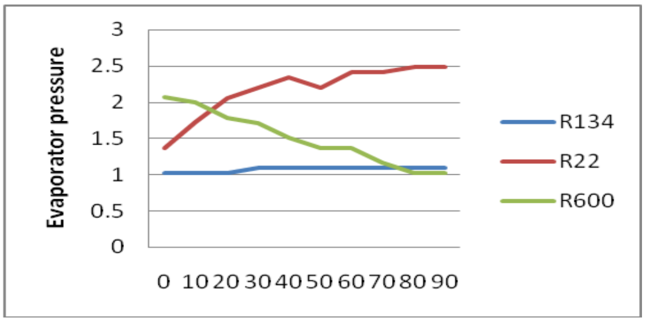

Figure4: Variation of Evaporator Pressure of VCR with Time

The evaporator pressure is found to increase in R22 refrigerant as compared to the R134a & R600a refrigerants and higher discharge pressure was recorded of 2.5 bar for R22 only. Whereas, In case of R600a the evaporator pressure is gradually decreases up to 1 bar.

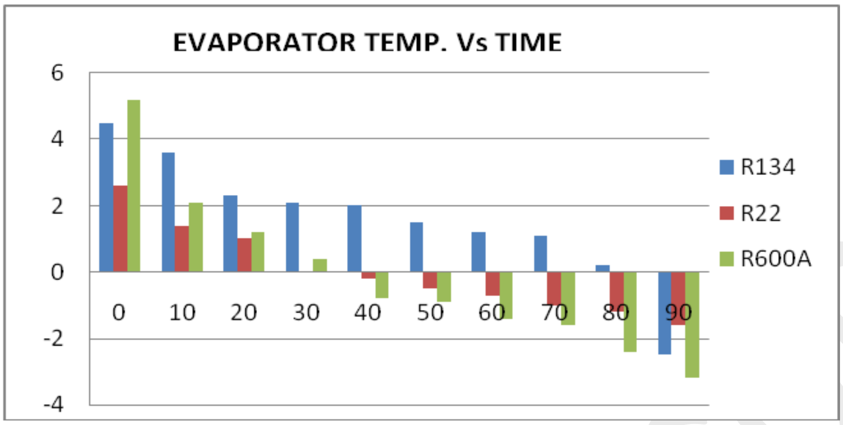

Figure 5: Variation of Evaporator inlet Temperature with Time

The Evaporator inlet temperature of VCR system is found to decrease fastly in R600a refrigerant as compared to the R134a & R22 refrigerants and in case of R22 the temperature of the temperature not decreases much by increase the period of time.

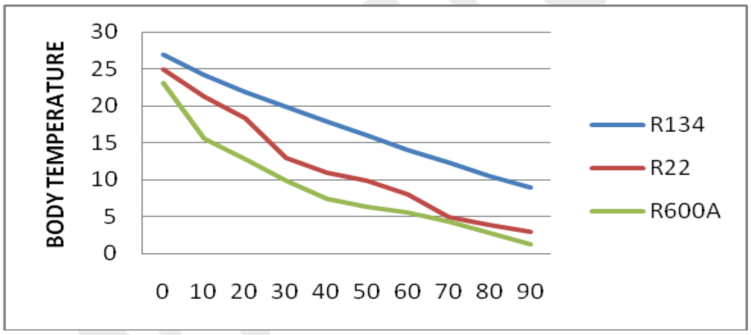

Figure 6: Variation of Body Temperature with Time

The body temperature of VCR system is found to decrease fastly in R600a refrigerant as compared to the R134a & R22 refrigerants and in case of R134a the temperature of the body not decreases much in less period of time.

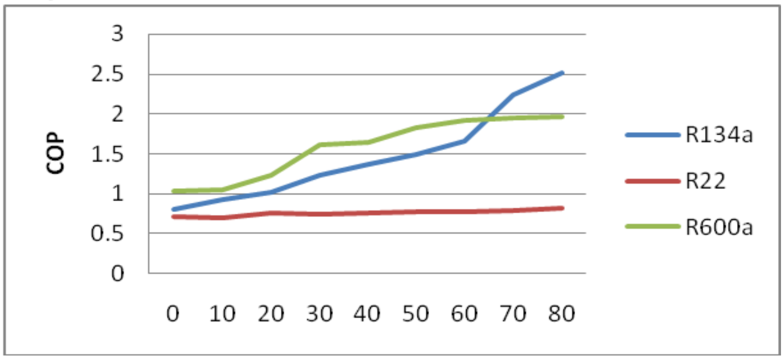

Figure 7: Variation of COP with Refrigerant Mixture

The COP value increases with changes of refrigerant in the refrigerant order of R22 the R134a and at last R600a.ixture and the highest value of COP found experimentally were 2.82.

CONCLUSION

1) The Refrigerant R600a & R134a is preferred over R22 works safely in the system without any system modification.
2) The discharge temperature & Pressure is found to increase with the changes of refrigerants and higher discharge pressure was recorded for R22 which can decrease the life period of compressor according to R600a and R134a.
3) The COP value increases and the maximum COP was obtained for R600a mixture.
4) Highest value of COP found experimentally is 2.82 actually.

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