Investigation of R152a/R134a Mixture in Refrigeration System

D.Sendil Kumar, Dr.R.Elancezhian

Abstract— In domestic refrigerators and refrigeration system the most widely used refrigerant is R134a. Refrigerant R134a has a high Global Warming Potential (GWP) of 1300. Hence an alternative for this refrigerant is to be identified. R152a is identified as an alternative to R12 and R134a refrigerants. In this paper an experimental investigation was made to reduce the usage of HFC 134a with the Hydrocarbon Refrigerant mixtures (HCM) of R134a and R152a refrigerants in the proportion 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 alternative for R134a.

Index Terms— Refrigeration, Refrigerant Mixture, Discharge Pressure, COP.

I. INTRODUCTION

The Refrigerant R12 and R134a as per ASHRAE classification are widely used in refrigeration and air conditioning systems. Due to high Ozone Layer Depleting Potential (ODP) and Global Warming Potential (GWP), R12 cannot be used in refrigeration system for long run. The concept of alternative refrigerant comes into picture. Investigating the alternatives, HFC 134a has got zero ODP whereas it is found to be not easily miscible with the conventional mineral oil used as lubricant in refrigerators [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 R134a consumes more power up to 10-15% [3]. The COP of the system was also found to be 3% less than the system with R12 refrigerant [4]. Hydrocarbon refrigerants also have got the problem of flammability [5]. R404a and R134a was investigated and compared with the results of R134a and found to be feasible [6]. Hydrocarbon mixture of R290/R600a as an alternative to R134a in a domestic refrigerator was experimented and found to give an improved higher COP of 3.25-3.6% [7]. The discharge temperature was found to be 8.5 K to 13.4 K lower than R134a [8].

II. THEORY OF REFRIGERATION

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 that of the surrounding temperature. Generally refrigeration systems can be classified in 3 main cycle systems which are vapor Compression refrigeration system, vapor absorption refrigeration system, and gas cycle refrigeration system. However the vapor compression refrigeration system is the most widely used in the refrigeration process. It is adequate for most refrigeration applications. The ordinary vapor compression refrigeration systems are simple, inexpensive, reliable and practically maintenance free. Most of the domestic refrigerators today are running based on the vapor compression refrigeration system. It is somewhat analogous to a reverse Rankine cycle. The vapor compression refrigeration 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 refrigerator.

Fig 1: T-S Diagram for +the Ideal Vapor Compression Refrigeration Cycle
There are different kinds of refrigeration systems according to different refrigeration temperatures. For low temperature refrigeration with temperature above -20°C, single stage refrigeration systems are used, below -20°C, two stage systems or compound systems are used. The primary refrigerant for these systems is R-22. However, R-22 will be phased out due to environmental issues. A proposed replacement is R-152a.

Fig 2: P-H Diagram for the Ideal Vapor Compression Refrigeration Cycle

III. 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 0.35 m/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 measured by a digital Watt-hr meter. A digital wattmeter is also connected with the experimental setup. Table 1. Summarized the characteristics of the instrumentation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Device</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Pt100, PID controller</td>
<td>-50 to 199°C</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressure Gauge</td>
<td>0-10 bar</td>
</tr>
<tr>
<td>Power</td>
<td>Digital Watt/Watt-h meter</td>
<td>5-20A</td>
</tr>
</tbody>
</table>

IV. EXPERIMENTAL PROCEDURE
The procedure for the conduction of experiments is as follows
(a) A performance test is made with the system loaded with pure R134a. The data is treated as the basis for the comparison with the refrigerant mixtures.
(b) Mixture of R152a and R134a by mass in the proportion 30:70, 50:50 and 70:30 was charged in the compressor and the performance tests were conducted.

V. RESULTS AND DISCUSSION

Fig.3: Variation of Discharge Temperature Of Compressor With Time

Fig.4: Variation of Discharge Pressure of Compressor with Time

Fig.5: Change in Evaporator Inlet and Outlet Temperature with Time

Fig.6: Variation of COP with Refrigerant Mixture
VI. CONCLUSION

(i) The mixture of R152a and R134a works safely in the system without any system modification.
(ii) 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 R134a.
(iii) The COP value increases and the maximum COP was obtained for 70:30 mixtures of R152a and R134a.
(iv) Highest value of COP found experimentally is 5.26.

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REFERENCES


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