Comparative Analysis of Vapour Compression Refrigeration System using Various Green Refrigerants

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Abstract— **The main objective of this work is to enhance the performance of the Vapour Compression refrigerator by flooding the evaporator with liquid refrigerant. The phase out schedule of a hydrochlorofluorocarbon refrigerant R134-a demands the development of an ecofriendly refrigerants. Since green refrigerants like carbon dioxide,ammonia etc., has wide ecological benefits like low ODP and low GWP. Hence this project work emphasis on the performance analysis of various ozone friendly refrigerants such as R717,R744 used in a vapour compression refrigeration system (VCRS). In this project work the performance test on Vapour Compression Refrigeration system using R134a(tetrafluoroethane), R717(ammonia) and R744(carbon dioxide) are calculated. On comparing COP's of green refrigerants R717 (ammonia, COPact=3.825) R744 (carbondioxide, COPact=2) R134-a (tetrafluoroethane, COPact=3.75), it is computed that R744 (carbon dioxide) has poor performance due to the high operating pressure and it is suggested that R717(ammonia) can also be used as green refrigerant in domestic refrigerator.**

Keywords – Vapour compression refrigeration system, Perfomance analysis, Ammonia, Carbon dioxide.

I. INTRODUCTION

Vapour compression refrigeration system is based on vapour compression cycle. Vapour compression refrigeration system is used in domestic refrigeration, food processing and cold storage, industrial refrigeration system, transport refrigeration and electronic cooling etc. So improvement of performance of system is too important for higher refrigerating effect or reduced power consumption for same refrigerating effect. Ashok Babu Puttaranga Setty Talanki et al [1] discussed about eight refrigerant blends consists of R290, R134a, R152a, R125and R32 at various compositions are developed. All the developed refrigerants possess zero ODP and low GWP compared to R22. The main goal of the study is to calculate the performance characteristics of actual VCR cycle using R22 and its various developed alternatives.AdriánMota et al [2] investigated the experimental influence of a high effectiveness IHX using R134a, and the low GWP mixture R513A (a mixture of R134a and R1234yf) under different evaporating and condensing conditions (29 points tested in total) Discharge temperature has been increased up to 26 K for both fluids, and the greatest compression ratio is not feasible for R134a. The cooling capacity of the system results increased up to 5.6% for R513A whereas for R134a is around 3%. Khurmi and Gupta [3] in their book gave evidence that the process of under cooling is also brought about by employing a heat exchanger. This increases refrigerating effect and finally improved coefficient of performance in vapour compression refrigeration system. Baskaran and Mathews [4] described systems including various refrigerants improved by analyzing the effect of the super heating / sub cooling case. Better performance coefficient values (COP) than those of nonsuper heating /sub cooling case are obtained.

II. SYSTEM DESCRIPTION AND DESIGN

Heat flows naturally from hot to colder body. But, in refrigeration system there is opposite phenomena i.e. heat flows from a cold to a hotter body. This is achieved by using a substance called a refrigerant. The refrigerant (R12) absorbs heat and hence evaporates at a low pressure to form a gas. This gas is then compressed to a higher pressure, such that it transfers the heat it has gained to ambient air or water and turns back (condenses) into a liquid. Thus, heat is absorbed, or removed, from a low temperature source and transferred to a higher temperature source. The refrigeration cycle can be broken down into the following stages as in Fig1.

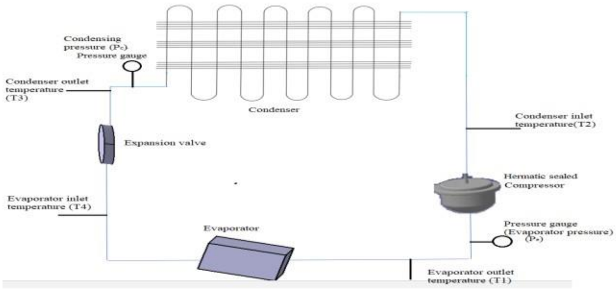


Fig.1. Layout of VCR System

Considering Fig.2,

1-2, the saturated vapour enters the compressor where its pressure is raised. There will also be a big increase in temperature, because a proportion of the energy input into the compression process is transferred to the refrigerant. 2-3, the high pressure superheated vapour passes from the compressor into the condenser. There will be decrease in temperature due to condensation process. The cooling for this process is usually achieved by using air. After condensation, refrigerant enters the expansion device. 3'-3, shell and coil heat exchanger is installed between the host refrigeration system compressor and condenser. Water is circulated through one side of heat exchanger and hot refrigerant gas from the compressor is routed through the other side. Heat is transferred from the hot refrigerant gas to the water thus refrigerating effect increases and power consumption or work input decreases. Thus performance of cycle is improved. Along with this waste heat also recovered. 3-4, the high-pressure liquid refrigerant passes through the expansion device, which both reduces its pressure and controls the flow into the evaporator. 4-1, Low pressure liquid refrigerant in the evaporator absorbs heat from its surroundings. During this process it changes its state from a liquid to a gas, and at the evaporator exit is slightly superheated.

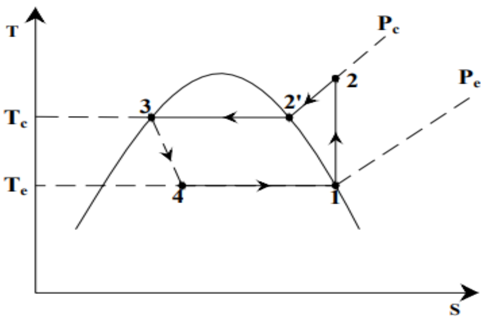


Fig.2.T-S Diagram of basic VCR

Based on T-s diagram of basic VCR as shown in Fig.2

$(COP)_{theoretical} = (h_1 - h_4) / (h_2 - h_1)$

$(COP)_{actual} = R_E / W$

$(COP)_{carnot} = T_L/(T_H - T_L)$

$W = (N_c \times 3600) / (T_c \times EMCC)$

$R_E = (N_h \times 3600) / (T_h \times EMCH)$

P_1, T_1 - Pressure and Temperature at Compressor

P_2, T_2 - Pressure and Temperature at Condenser

P_3, T_3 - Pressure and Temperature at Expansion Device

P_4, T_4 - Pressure and Temperature at Evaporator

Pc - Condensing pressure

Pe - Evaporator pressure

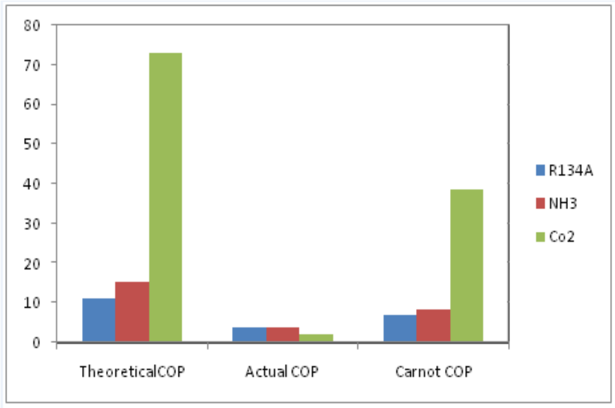
T_1 - Evaporator outlet

T_2 - Condenser inlet

T_3 - Condenser outlet

T_4 - Evaporator inlet

IV. RESULTS AND DISCUSSION



For a single-stage vapour compression system both R717 and R744 exhibits higher COPs when compared with R134a. R744 showed the highest coefficient of performance with increasing condensing temperature and evaporating temperature.Materials research in the context of vapor compression systems has shown that ammonia, carbon dioxide, natural refrigerators are halogen free and are safe for the environment but the throttling loss is very large as compared to conventional refrigeration systems due to the higher pressure change during the expansion.

V. CONCLUSIONS

1. The performance of a vapour compression refrigerator was investigated using R134-a,R717 and R744 as green refrigerants. This analysis is aimed at comparing the performance characteristics of the refrigerator working with R134a. Based on the performance analysis, the following conclusions are drawn:
2. In this project work the performance test on Vapour Compression Refrigeration system using R134a(tetrafluoroethane), R717(ammonia) and R744(carbon dioxide) are calculated.On comparing COP's of greenrefrigerants R717 (ammonia, COP_{act}=3.825) R744 (carbondioxide, COP_{act}=2) R134-a (tetrafluoroethane, COP_{act}=3.75), it is computed that R744 (carbon dioxide) showed poor performance due to requirement of high operating pressure. It is suggested that R717(ammonia) can also be used as green refrigerant in home refrigerator.

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