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“Performance Analysis of Mixtures of R290 and R600a With Respect To R134a in Simple Vapour Compression Refrigeration System”

Mausami Hemantsinh Gohli¹, Dr. Sandeep M.Salodkar², Nitesh Rane³

M.Tech Scholar¹, Professor², Asst. Professor³

^{1,2,3}Department of Mechanical Engineering, Dr. APJ Abdul Kalam University, Indore

ABSTRACT

Refrigeration is a process for maintaining a temperature below the surrounding temperature. Tetrafluoroethane R134 is commonly used as a refrigerant in domestic refrigeration after 2000, before that halogenated refrigerants R12 were used in refrigeration which responsible for ozone layer depletion which act as armor for preventing us from ultraviolet radiation. Refrigerant R134a has zero ozone layer depletion (OLD) but higher rate of global warming potential (GWP) and after Kyoto protocol global warming is serious issue as it increases the overall temperature of our surroundings and then arising the need of alternate refrigerants that can be used in place of refrigerant R134a (Tetrafluoroethane) in domestic refrigerator. In this paper, study has been done on the alternative refrigerant for replacing the traditional refrigerant R134a. Various researchers working for the find a alternative refrigerant with higher coefficient of performance and cooling effect. Many researchers investigated the blend of propane and isobutane (R290 & R600a) which is a pure hydrocarbon refrigerants which have the almost same thermodynamic physical properties as of Tetrafluoroethane refrigerants. In this paper reviewed the various research works for selecting the blend of refrigerant, acceptable thermo-physical properties, blend in various proportion and operating parameters.

KEYWORDS: Alternative refrigerants, Global warming potential, Ozone layer depletion and thermo-physical properties.

INTRODUCTION

Refrigeration is used for maintaining the temperature below to the surroundings and a lot of application of refrigeration such as food processing industries, textile industries, medical plant, cold storages and it represents a significant proportion of overall site energy costs. Presently, due to increase in global warming of system it is very much necessary to study about the refrigeration systems that are used now days. The refrigeration systems instantly needs technical information how to minimize the global warming that is increased by the refrigerants by finding some alternate refrigerant that can be used in place of traditional refrigerant.

Vapor-Compression Refrigeration Systems: Vapor-compression refrigeration systems are the most normally used refrigeration systems used in domestic refrigerator. and each system employs a compressor. In vapor-compression refrigeration cycle four thermal processes take place as follows:

- Evaporation,
- Compression,
- Condensation, and
- Expanion

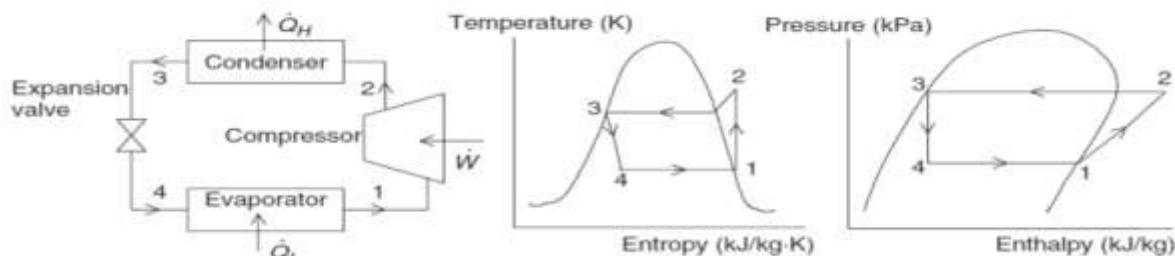


Figure 1: Block diagram T-S and p-h cycle of vapor compression system

REFRIGERANTS

The refrigerant is a heat carrying substance which during vapor compression cycle in the refrigeration system. Refrigerants absorb heat from a low temperature system and dissipate the heat so absorbed to a higher temperature system. The natural ice and a mixture of ice and salt were the first refrigerants. In 1834, ether, ammonia, sulphur dioxide, methyl chloride and carbon dioxide came into use as refrigerants in compression cycle refrigeration machines. Most of the early refrigerant materials have been discarded for safety reasons or for lack of chemical or thermal stability. In the present days, many new refrigerants including halo-carbon compounds, hydro-carbon compounds are used for air conditioning and refrigeration applications.

The suitability of a refrigerant for a certain application is determined by its physical, thermodynamic, chemical properties and by various practical factors. There is no one refrigerant which can be used for all types of applications i.e., there is no ideal refrigerant. If one refrigerant has certain good advantages, it will have some disadvantages also. Hence, a refrigerant is chosen which has greater advantages and less disadvantages.

Classification of Refrigerants

This section is focused only on the primary refrigerants, which can be classified into the following five main groups:

- Halocarbons,
- Hydrocarbons (HCs),
- Inorganic compounds,
- Azeotropic mixtures, and
- Nonazeotropic mixtures

LITERATURE REVIEW

Shrikant Dhavale and Dr. Manish Deshmukh study were based on the experimental study of performance simulation of blending of R600a and R290 eco-friendly refrigerants. In this research work, thermodynamic performance were observed for blend of hydrocarbon R600a and R290 and its performance is compared with R134a refrigerant. Experimental work carried out some observation that the coefficient of performance and refrigerating capacity of the R290, R600 and R600a refrigerant mixtures in various proportions with increasing evaporator temperature and decreases with constant condensing temperature. The compressor power consumption was higher with the refrigerants R290/R600 (70/30), R290/R600a (50/50), R290/R600 (40/60), R290/R600 (60/40) and R290/R600a (30/70) for the various range of operating condition. The observation found that COP of blend of R290/R600 (40%/60%) was higher at the lower evaporator temperature and slightly higher at higher evaporator temperature than R12 and R134a refrigerant.[2]

Yongchan Kim et. al. has discussed the performance evolution of mixture of R290 and R600a in 55%/45% proportion were used as alternative refrigerant to R134a in a small-capacity cooled refrigerator and compressor displacement volume of the alternative system were modified from the original system R134a to match the refrigeration capacity. The refrigerant charge and capillary tube length for R134a were 100 g and 3000/3000/ 6000 mm, respectively, while those for the optimized R290/ R600a were 50 g and 3500/3500/6500 mm, respectively. The refrigerant charge and capillary tube length for R134a were 100 g and 3000/3000/ 6000 mm, respectively, while those for the R290/ R600a were 50 g and 3500/3500/6500 mm, respectively. The blend of R290 and R600a refrigerant offered best performance to the R134a refrigerant and both were tested. Blend of refrigerant of R290 and R600 were tested in 500 mm longer length of capillary tube of evaporator than those in R134a. The power consumption and cooling speed were 12.3% lower than the R134a and improved 28.8% over the R134a because R290/R600a have relatively high heat transfer performance and slightly higher operating pressure. [3]

Gaurav and Raj Kumar has discussed the comparison between the energy and exergy analysis of domestic refrigerator with eco-friendly refrigerants. The exergy gives a measure the magnitude of waste of energy depends on energy supplied. It established the efficiency defect is maximum in condenser and lowest in evaporator and comparison of

various properties for alternative refrigerants has been done for a domestic refrigerator. Finally concluded that R152a has the highest value of COP, R600 has the highest value of EDR at 40°C but at 55°C R600a has the highest value of EDR, R600a has the highest value of Efficiency defect in compressor, R290 has the highest value of Efficiency defect in throttle valve, R152a has the highest value of Efficiency defect in condenser in evaporator, Condenser has highest value of efficiency defect followed by compressor, throttle valve and evaporator and R152a has highest value of exergetic efficiency R600a when T_o varies between 25°C and 55°C, $T_e = 0^\circ\text{C}$, $T_c = 55^\circ\text{C}$ but R290 has highest value of EDR for the same condition. [4]

Sopan R. Arote and D. D. Palande worked on the investigation of the hydrocarbon refrigerant mixture of R600a (Isobutane) and R290 (Propane) for the replacing and alternative of R134a in a single evaporator refrigerator. The performance parameters of optimized blend of R600a (Isobutane) and R290 (Propane) refrigerant were evaluated and compared with performance of R134a refrigerant. The performance results of blended refrigerant and R134a and comparative analysis were validate with the help of REFPROP and analyzing the performance of refrigeration cycle hermetically sealed compressor were used. [5]

Mohd. Aasim Nazeer Ahmad Quraishi and U. S.Wankhede has been studied the performance of the hydro chloro fluoro carbons and hydro fluoro carbons. Hydro fluoro carbons were used at the place of hydro chloro fluoro carbons, the system performance were decreased with increased consumption of energy. In this research work, nano-particles were blended with the refrigerant and blend of refrigerant delivered high performance and low energy consumption than pure refrigerant. The nano-particles changed thermo physical properties change and depend it depends on the concentration of the nano-particles in blend of refrigerant. The refrigerator given high performance compared with pure refrigerant and at reduced energy consumption. [6]

Jitendra Kumar Verma has worked for the reducing the toxic and hazardous effect of refrigerant on the humans and environment by use of blend of eco-friendly refrigerants. Conventional, fluorocarbons and chlorofluorocarbons were used in domestic refrigerator systems but it depletes the ozone layer. The common used refrigerants are non-halogenated hydrocarbons, sulfur dioxide and ammonia. Presently, R134a is used in domestic refrigerators, but refrigerant R134a in contact with flames or hot surfaces produces hazardous and toxic effect. Kyoto protocol suggested the use of natural refrigerants because it leads to minimum GWP and Zero ozone layer depletion. [7]

N. Austin Dr. P. Senthil Kumar Dr. P. M. Diaz have studied alternative refrigerant of R134a because of R134a refrigerants has high global warming potential and is expensive. Due to this, Investigated the application of mixtures of hydrocarbon R290, R600 and R600a to replace the R134a refrigerant in household refrigeration system. These hydrocarbons have zero ozone depletion potential and negligible GWP. The refrigerator worked efficiently when mixed refrigerant was used as refrigerant instead of R134a. The evaporator temperature reached -21°C with COP value of 3.24 and an ambient temperature of 30°C in the mixture- 2(15%R134a/40%R290/ 40%R600a/5% R600) is used as alternate refrigerant to the traditional refrigerant R134a. The results of the present work indicate the successful use of this mixed refrigerant as an alternative to R134a in domestic refrigerators. [8]

K. Mani et. al. developed the model for performance analysis of hydrocarbon mixture refrigerant R290%/R600% (79%/21%) as an alternative to R12 and R134a. Experiments were performed using mixture of R290/R600, R12 and R134 refrigerant at various evaporating and condensing temperatures and at different compressor speeds and performance parameters of vapour compression refrigeration system were compared. The mixture of refrigerant R290 and R600 showed 19.3 – 27.9 % higher COP and 49% higher for lower T_e temperatures and 30% higher for higher T_e than refrigerant of R12 and R134a. The result showed that mixture of R290 and R600 (79%/21%) can be used as a alternative of R12 and R134a. [9]

CONCLUSION

Study of literature of alternative refrigerant carried out a lot of information about the environment friendly, selection of the refrigerants for blend, various different weight proportion of refrigerants in blend and thermo-physical properties and performance and efficiency of refrigerants and refrigeration systems. The following conclusion is drawn from previous research observations:

1. The refrigerant R134 have a high global warming potential while the alternative refrigerant blend of refrigerants have low global warming potential with zero ozone layer depletion factor and also not produces toxic and hazardous effect on environment.
2. Blend of refrigerants R290/R600a were used in refrigeration system when power consumption and cooling speed were 12.3% lower than the R134a and improved 28.8% over the R134a because R290/R600a have relatively high heat transfer performance and slightly higher operating pressure.
3. The refrigerator worked efficiently when mixed refrigerant was used as refrigerant instead of R134a. The experimental observation of the previous research works the successful use of this mixed refrigerant as an alternative to R134a in domestic refrigerators.

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