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EXPERIMENTAL STUDIES OF VCR CYCLE BY USING VARYING REFRIGERANT AND CHARGING CONDITION

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Abstract-

This work aims for development of one of the eco-friendly vapour compression refrigeration system. The present vapour compression refrigeration system. Uses R-134a refrigerant, which has many adverse effects, which is minimized by use of other alternative refrigerant. This work consists of using eco-friendly hydrocarbon gas mixture as refrigerant, which does not deplete ozone layer and it can be used in the commonly used system without any significant change in the system. In this analysis, the performance of vapour compression refrigeration system is assessed experimentally with two different refrigerants. Various parameters are measured, like compressor discharge temperature and pressure. The results obtained are compared and the optimum performance in terms of higher refrigeration effect, Charging condition of refrigerant and COP are studied.

Keywords— Vapour Compression Refrigeration system, R-134a, Hydrocarbon refrigerants, Coefficient of Performance.

I. INTRODUCTION

Refrigerators are one of the major energy consuming appliances in household environment . R134a is the most widely used refrigerant in domestic refrigerators, due to its good thermodynamic and thermophysical properties. In India, about 80% of the domestic refrigerators use R134a as refrigerant but its GWP (Global Warming Potential) effect is 1300. The Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) asked for reduction in emission of six categories of greenhouse gases, including R134a, used as refrigerant in domestic refrigerators to prevent global warming Therefore, according to Kyoto protocol the consumption of R134a must be seriously reduced Halogenated refrigerants used in vapor compression based refrigeration, air conditioning and heat pump systems cause greenhouse gas emissions which, in turn, contribute significantly to the global warming. One effective solution to reduce this type of greenhouse gas emissions is using environment friendly and energy efficient refrigerants.

It is reported that, there is no single refrigerant or mixture available to satisfy both the Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) issues. The use of mixtures of refrigerant has proved to be an excellent substitute for the menacing refrigerant R134a. Theoretical modelling is one of the most widely accepted practices to study the performance of vapour compression refrigeration system with environmental friendly refrigerants.

This paper deals with the theoretical study and prediction of performance of the vapour compression refrigeration system with R134a and the selected hydrocarbon refrigerants.

II. HISTORY OF REFRIGERANT

The working fluid used to transfer the heat from low temperature reservoir to high temperature reservoir is called refrigerant. There are different types of refrigerant which are dissuasion below.

A. *CFC*: They are molecules composed of carbon, chlorine and fluorine. It contributes to the destruction of the ozone layer. These are R11, R12, R113, R500, R502 etc.

B. *HCFC*: They are molecules composed of carbon, chlorine, fluorine and hydrogen. They are less stable than CFCs, destroy ozone and to a lesser extent. These are R22, R123, R124, R401a etc.

C. *HFC*: They are molecules composed of carbon, fluorine and hydrogen. They do not contain chlorine and therefore do not participate in the destruction of the ozone layer. But it has a high Global Warming Potential (GWP).

D. *Hydrocarbons (HC):* This is primarily propane (R290), butane (R600) and isobutene (R600a). These fluids have good thermodynamic properties, but are dangerous because of their flammability.

III. ENVIRONMENT CONCERN

The first major concern is depletion of ozone layer. Ozone layer is a layer which protects the earth from ultraviolet rays. Ozone depletion potential is evaluated on a scale that uses CFC-11 as a benchmark. All the other components are based on how damaging to the ozon layer. They are in relation to CFC-11.The second major concern is global warming. Global warming is the increase in global earth surface temperature due to the absorption of infrared emission from earth surface. Global warming potential is evaluated on a scale that uses CO2 as the bench mark i.e. CO2 is assigned a value and other components are compared to CO2. Hence, Kyoto protocol established the phased out of HFCs in the near future. Montreal and Kyoto protocols are interconnected, total climate change and ozone depletion depends on both the global warming potential and ozone depletion potential of the substances. Alternative to HFC refrigerants can be HC (Hydrocarbon) as there is n fluorine content. Hydrocarbons (HCs) are the class of natural occurring substances that include propane, pentane and butane. HCs are excellent refrigerants in many ways energy efficiency, critical point, solubility, transport, heat transfer properties and environmentally sound but their major concern is their flammability.

IV. ANALYSIS OF VAPOUR COMPRESSION REFRIGERATION CYCLE

Figure 1 shows the refrigeration cycle on p-h diagram. The refrigerant evaporates entirely in the evaporator and produces the refrigerating effect. It is then extracted by the compressor at state point 1, compressor suction, and is compressed isentropic ally from state point 1 to 2. It is next condensed to liquid in the condenser, and the latent heat of condensation is rejected to the heat sink. The liquid refrigerant, at state point 3, flows through an expansion valve, which reduces it to the evaporating pressure.In the ideal vapour compression cycle, the throttling process at the expansion valve is the only irreversible process, usually indicated by a dotted line. Some of the liquid flashes into vapor and enters the evaporator at state point 4. The remaining liquid portion evaporates at the evaporating temperature, thus completing the cycle.

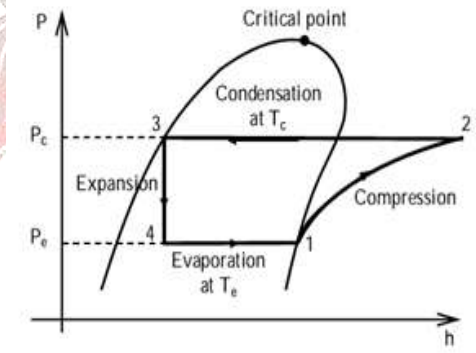

Fig1:p-h Vapour Compression Refrigeration Cycle

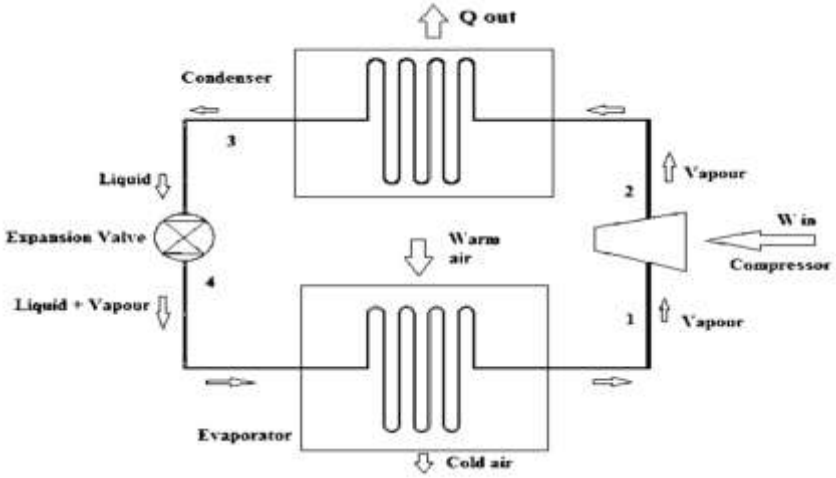

Fig2:Simple Vapour Compression Refrigeration cycle

The refrigeration process that employed in the domestic refrigerator is based on a vapor compression cycle as shown in Figure 2.There are three main parameter that were considered in this study; compressor power, refrigeration capacity and coefficient of performance (COP)

Process line from 1 to 2 represents compressor power: Compressor power is defined as the power needed to do the compression process in watt.

$P = m (h2-h1)$ (1)

Process from point 2 to 3 represents heat rejection through condenser.

$Qin = m (h1-h4)$ (2)

The coefficient of performance (COP): The COP of a domestic refrigerator is the ratio of the refrigeration capacity to the energy supplied to the compressor.

$COP = Qin/p$

$=m(h1-h4)/m(h2-h1)$ (3)

V. PROPERTIES OF REFRIGERANT

PROPERTIES OF REFRIGERANT

Properties of Refrigerant	Molecular Weight (g)	Boiling Point ©	Melting Point (c)	Flammability Limit in Air	O.D.P	GWP
R134a	102.3	-26.1	-103.3	None	0	1200
R600a	58.1	-11.6	-159.42	Flammable	0	0.0011

VI. ADVANTAGES OF HYDROCARBONS

Hydrocarbons (HCs) are very good refrigerants for many reasons:

- They are compatible with copper and the standard mineral oils. They have a very low environmental impact in comparison with CFCs, HCFCs and HFCs.
- They perform very well, with good capacity and efficiency
  Due to lower liquid densities, low refrigerant charge than that of HFCs then the high heat transfer coefficients hence high latent heat of vaporization
- Coefficient performance (COP) of the system increases and Power consumption reduced with HCs; Improves compressor life due to low discharge temperature compare to HFCs, HCFCs and CFCs.

VII. LITERATURE REVIEW

Jwo, and C.C. Ting. [1] Their investigation aims to apply the mixture of hydrocarbon refrigerants, R-290 and R-600a with each 50% component ratio, instead of the refrigerant R-134a for home refrigerators. During test the official R-134a refrigerant was replaced by varied mass hydrocarbon refrigerant, which was mixed by R-290 and R-600a with each 50% component ratio. The results show that refrigerating effect is improved by using hydrocarbon refrigerant. Moreover, the total power consumed is saved 4.4% and applied mass of refrigerant is reduced 40%.

Wongwises. [2] performed the theoretical study on traditional vapor compression refrigeration system with refrigerant mixtures based on HFC134a, HFC152a, HFC32, HC290, HC1270, HC600 and HC600a for various ratios and their results are compared with CFC12, CFC22 and CFC134a as possible alternative replacement.

Considering the comparison of coefficient of performance (COP) and pressure ratio of tested refrigerants and also the main environmental impacts of ozone layer depletion and global warming, refrigerant blends of HC290 (40%) + HC600a (60%) and HC290 (20%)+HC1270 (80%) are found to be the most suitable alternatives among refrigerants tested for R12 and R22 respectively. The refrigeration efficiency, coefficient of performance (COP) of the system increases with increasing evaporating temperature for a constant condensing temperature. Similarly Hc22a can be tested for R-134a

Sattar [3] designed a domestic refrigerator to work with R-134a and was used as test unit to determine the possibility of using hydrocarbons and their blends as refrigerants. Pure butane, isobutene and mixture of propane, butane and isobutene were used as refrigerants. The performance of refrigerator using hydrocarbons as refrigerants was investigated and compared with the performance of refrigerator when R-134a was used as a refrigerant. In this experiment effect of condenser temperature and evaporator temperature on COP, refrigerating effect. Condenser duty, work of compression and heat rejection ratio were investigated. After successful investigation on the performance of hydrocarbon and blends of hydrocarbon refrigerants it is found that COP of the system is comparable to R-134a and also energy consumption is similar to R-134a. This suggests that blends of hydrocarbon can be used as an alternative to R-134.

Tiwari [4] performed an analysis on vapour compression refrigeration system by using four ozone friendly hydro-fluorocarbon HFC refrigerants R125, R134a, R143a and R152a to replace R-12. The experiment was done to evaluate the coefficient of performance (COP), refrigerating capacity (RC) and compressor work at various evaporating and condensing temperature.
Among all the tested refrigerants R152 has higher coefficient of performance (COP), higher refrigerating capacity than R12, while R134a has a slightly lower COP and higher refrigerating capacity than R12. On the basis of this study HC22a which is also an eco-friendly refrigerant can be evaluated for its COP and refrigerating capacity.
domestic refrigerator. The COP and other result obtained in this experiment show a positive indication of using HC as refrigerants in domestic refrigerator.
Chavhan [5] have presented the study on refrigerator using R134a. R134a is having zero ozone depletion potential (ODP) and almost same thermodynamic properties as R12, but it has a high
Austin [6] had presented the study on refrigerator using mixed refrigerants. The Mixed Refrigerants (hydrocarbons mixtures propane, and isobutene) and compared with the performance of refrigerator with R-134a was used as refrigerant. The effect of condenser temperature and evaporator temperature on COP, refrigerating effect was investigated. The energy consumption of the refrigerator during experiment with mixed refrigerants and R-134a was measured.
Bolaji [7]provided comparative experimental steady is carried out of there refrigerator R-152a R-32 & R-134a to replace R-134a R-152a & R-32 are new refrigerant having zero ODP & GWP finally, he considered that Cop of R-152a 4.7% higher than R-134a & Cop of R-32 is 8.5% less than R- 134a. Pull down time is achieved early than R-32. Power is considerably reduced with R-152a than the R-32 R-134a
Mani [8], have analyzed a vapor compression refrigeration system with the new R290/R600a refrigerant mixture as drop-in replacement was conducted and compared with R12 and R134a. The VCRS was initially designed to operate with R12.The results showed that the refrigerant R134a showed slightly lower COP than R12. The discharge temperature and.
Dr. periyasamy [9], has experimental studies on a vapour compression refrigeration system using hydrocarbon and R12 refrigerant This mixture provides better performance in terms of heat rejection rate and COP .The heat rejection rateis increased by 50% and COP is incrased30%with hydrocarbon mixture.
D.Y Goswami. [10],has concluded that concluded that the level of charge greatly affects the performance of air conditioning systems. For charge levels down to 90 per cent the effect is negligible. However, for charge levels of 80 per cent or below the steady-state cooling capacity and the COP may be zero or even negative.

CONCLUSION

The refrigeration analysis was performed experimentally for different refrigerant mixtures for vapour compression refrigeration system and from the analysis it is concluded that,

- Hydrocarbon refrigerant are having less impact on the environment in terms of global warming based on the heat rejection rate.
- In domestic refrigerators and industrial refrigeration systems, the mixture of R-290 & R- 600a can be used as alternate refrigerant instead of R-12 and R-134a.
- Refrigerant leakage causes low level of charge resulting in a lower thermal performance and higher operating cost.

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