Vapour Compression Refrigeration System Working on Ecofriendly Refrigerant: A Review

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Abstract— The number of eco-friendly refrigerants are used in vapour compression refrigeration system like HFC152a, HFC32, HC290, HC1270, HC600, HC600a, RE170.The results showed that the alternative refrigerants investigated in the analysis RE170, R152a and R600a have a slightly higher COP than R134a for condensation temperature 50 °C and evaporating temperature -30 °C and 10°C. RE170 refrigerant replace the R134a refrigerant and HC290 & HC600a refrigerants replace the R22 refrigerant. At concept of ODP (ozone depleting potential) and GWP (global warming potential) refrigerant R152a will be batter alternative refrigerant than R134a in refrigeration system. The effects of the main parameters of performance analysis such as refrigerant type, sub-cooling and superheating on the refrigerating effect, coefficient of performance and volumetric refrigeration capacity wear also investigated for various evaporating temperatures.

Key words: Vapour Compression, Ecofriendly Refrigerant, GWP

I. INTRODUCTION

The global warming potential (GWP) and ozone depleting potential (ODP) have become the most important criteria in the developments of new refrigerants apart from the refrigerants CFCs and HCFC due to their contribution to ozone layer depletion and global warming. Therefore, hydro fluoro carbon (HFC) and hydro carbon (HC) with zero ODP use in many industrial area and domestic application. Under Kyoto protocol of united nation frame work convention on climate change (UNFCCC) the HFC refrigerants are selected for refrigeration system. Kyoto protocol was approved by many nations called for reduction in emission of greenhouse gas including HFC refrigerants.

Many investigations have been conducted on the research into substitutes for CFC12, CFC22 and HFC134a. B.O.Bolaji [6] performed experimental study of R152a to replace R134a in domestic refrigerator. Accorading to result of experiments, the average COP obtained using R152a is higher than R134a. A. Baskaran and P. Koshy Mathews [4] study on different refrigerants. Accorading to result RE170 will be better refrigerant in VCR system due to COP of RE170 is higher than R134a for condensation temperature 50 °C and evaporating temperature -30 °C and 10°C. Mehadi Rasti [5] study about two hydrocarbon refrigerants instead of R134a in domestic refrigerator. The effect of parameter including refrigerant type, refrigerent charge and compressor type are investigated. In this research is conducted using R436A (mixture of 46% iso-butane & 54% propane) and R600a (pure iso-butane) as hydrocarbon refrigerents. HC mixture consisting of propane and iso-butane replace the R134a in domestic refrigerator with reduction energy consumption rate of HC type compressor. Dr. A.C. Tiwari and Shyam Kumar Barode [3] study on four ozone-friendly Hydrofluorocarbon (HFC) refrigerants (R125, R134a, R143a and R152a). The performance in term of coefficient of performance (COP), refrigerating capacity (RC), and compressor work were evaluated for the investigated refrigerants at various evaporating and condensing temperatures. The system performance increases as the evaporating temperature increases, but reduces as the condensing temperature increases. R152a offers the best desirable environmental requirements, zero Ozone Depleting Potential (ODP) and very low Global Warming Potential (GWP). R152 has higher coefficient of performance (COP), higher refrigerating capacity than R12. Therefore, R152 will be preferred as working fluid in vapour compression refrigeration system. M. Mohanraj, S. Jayraj, C. muraleedharan [2] say that most of the vapour compression refrigeration system continue to run on halogenated refrigerants due to it's excellent thermodynamic properties apart from the low cost. But, the halogenated refrigerant affect on ODP and GWP. They reviews the various experimental & theoretical studies carried out around the globe with environment friendly alternatives such as HC, HFC and their mixtures. The halogenated refrigerants have a long history of emission from refrigeration, air conditioning & other uses. The emission of chlorine and flourine atoms present in halogenated refrigerents is responsibal for the major environmental impacts. The R152a are found to be better substitutes for R12 and R134a in domestic refrigeration sector. Dalkilic and wongwises [1] presented an experimental study on the application hydrocarbon mixture to replace HFC134a in air conditioners. The HC investigated are propane (R290), butane (R600), isobutane (R600a). The effects of the main parameters of performance analysis such as refrigerant type , degree of subcooling and superheating on the refrigerating effect (RE), coefficient of performance (COP) are investigated for condensation temperature 50 °C and evaporating temperature -30 °C and 10°C.

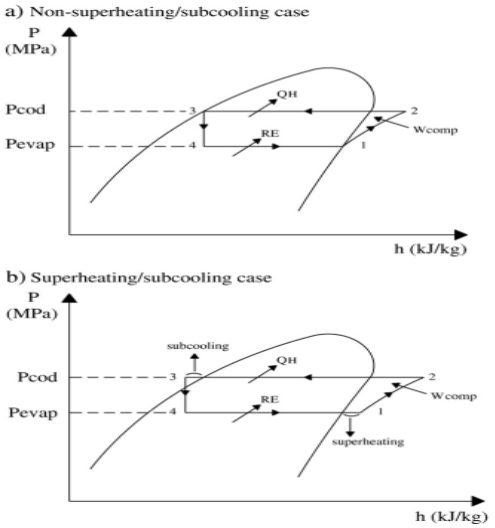

Fig: (a) non-superheating/subcooling

(b) superheating/subcooling

II. NOMENCLATURE

- CFCs Chlorofluorocarbons
- COP Coefficient of Performance
- GWP Global Warming Potential
- ODP Ozone Depletion potential
- HCFCs Hydro Chlorofluorocarbons
- HCs Hydrocarbons
- HFCs Hydro Fluorocabons
- RE Refrigerating Effect KJ/Kg

III. THE GENERATION OF REFRIGERANTS

1st Generation of refrigerant
Aim: whatever worked Ether, CO2, NH3, H2O, CC, etc.
2nd Generation of refrigerant
Aim: safely and durability, CFC, HCFCs, NH3, H2O, etc.
3rd Generation of refrigerant
Aim: protection of the ozone HCFCs, HFCs, CO2, NH3,etc
4th Generation of refrigerant
Aim: Centre at global warming

In the process of searching for new alternative, by mixing two or more refrigerants a new working fluid with the desired characteristic can be developed. Problem with blend of refrigerants is that not all of the properties can match the original refrigerant under all conditions. R12 for example will rarely match the pressure at all point in the desired temperature range. The mixture of refrigerants could be Azeotropic, in which two or more refrigerants with similar boiling point acts as a single fluid. The components of the mixture will not separate under normal operating conditions and can be charged as a vapour or liquid. The near Azeotrope mixture consist of two or more refrigerants with different boiling points, when in liquid or vapour state, act as one component. When changing from vapour to liquid or liquid to vapour, the individual refrigerant evaporates or condenses at different temperatures. The Zoetrope which is a mixture made up of two or more refrigerants with different boiling points, they are charged in the liquid state.

A. Mixture of Refrigerants:

They can be classified according to the type of fluorinated components,

- Zeotropic- The state can be changed (condensation, evaporation) the temperature varies. EX: R404a, R407a, R410a
- Azeotropes - With no change in temperature during the change of state EX: R500, R502, R507

B. Ammonia (NH3) or R717:

Have an excellent refrigerant for evaporation temperatures between -35 °C to 2 °C. But, NH3 is toxic and flammable.so, it used in industrial refrigeration.

C. Hydrocarbons (HC) as R290, R600a:

Have good thermodynamic properties. But, HC is flammable.

Their future use in air conditioning seems unlikely, given the cost of setting both mechanical and electrical safety.

D. Carbon dioxide (CO2) or R744:

R744 is inorganic, non-toxic, and non-flammable. But, inefficient in thermodynamics

It is use in high pressure and special compressors. The value of ODP=0 and GWP=1 for R744.

The low specific volume resulting in facilities with low volume

Have a low critical temperature at 31 °C and pressure of 73.6 bars.

E. HFC-R152a:

The molecule is similar to R-134a except that two hydrogen atoms are substituted for two fluorine atoms. It has similar operating characteristics to R-134a but cools even better. An environmental benefit of HFC-152a is that it has a global warming rating of 120, which is 10 times less than R-134a, but still a lot higher than CO2. That is why HFC-152a is currently used in many aerosol products as a propellant. Its main drawback is that it is slightly flammable.

Mathematical Relations:

R.E = Refrigerating Effect KJ/Kg or heat abstraction in evaporator.
W = work of compressor KJ/Kg
COP = R.E/W

IV. RESTRICTIONS FOR USE OF REFRIGERANTS

The nature refrigerants, such as ammonia, hydrocarbons and CO2 The disadvantages of these products are mainly toxicity (NH3), flammability (HC) and high pressures (CO2). So, the nature refrigerants are discarded from system of refrigeration. Some refrigerants are banned due to their high ozone depletion potential (ODP) and global warming potential (GWP).

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 ozone 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.

A. Montreal Protocol:

In 1987 Montreal protocol established the requirements that began the world – wide phase out of CFCs.
Production of CFCs was phased out by the Montreal Protocol in developed countries in 1st of January, 1996. Production in developing countries was phased out in 2010. In 1992 Montreal protocol established the requirements that began the world – wide phase out of HCFCs. Complete production of HCFCs will be phased out by Montreal protocol in 2030.

B. Kyoto Protocol:

In 1997, in Kyoto, Japan 150 countries initiated an agreement to reduce the emanation of greenhouse gases. Though Carbon Dioxide was the main irritant, HFCs also

formed part of other 5 such gases. The agreement is known as Kyoto Protocol.

The effect of this protocol is not only on refrigerants alone but also on the energy efficiency of the system as a whole. The efficiency of energy use by a system would be assessed on the basis of Carbon Dioxide released to produce that energy.

Kyoto protocol aims at phasing out of substances that will lead to global warming. R134a is used in domestic refrigerator and other vapour compression systems as it was identified as a replacement to CFC-12, keeping in view its zero ozone depleting potential. R134a has 1300 global

V. FACTORS AFFECTING THE PERFORMANCE OF VAPOUR COMPRESSION REFRIGERATION SYSTEM

From the literature survey it is observed that following factors affect the performance of vapour compression refrigeration system.

- Properties of working fluid.
- Mixture proportions of different refrigerants.
- Suction pressure.
- Discharge pressure.
- Pressure ratio.
- Amount of charge filled.
- Dimensions of capillary tubes

VI. CONCLUSION

Researchers have carried out experimental investigations to find out the various factors affecting the performance of vapour compression refrigeration system. Working fluid properties, mixture proportions, suction and discharge pressure, dimensions of capillary tubes, amount of charge affect the performance of refrigeration system.

From the basis of researchers the eco-friendly refrigerants which having zero value of ODP and lowest value of GWP also improve COP system with refrigeration effect are selected for refrigeration system. All systems including various refrigerant blends were improved by analysing the effect of the superheating/subcooling case.

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