Mathematical Performance Analysis of VCR cycle using R 22, R410A & R744 as a Refrigerant

Dinesh Barfa[1] Mr. Devendra Sikarwar[2] Mr. Ashish patidar[3]
[1]PG Scholar [2]Professor & Head of Dept. Assistant Professor [3]Co-ordinator Assistant Professor
Patel College of Science and Technology, Indore

Abstract— Conditioning of air is not a new process; In the early centaury before 2000 for air conditioning we are using R-22 difluoromonochloromethane. The application of this refrigerant is obsolete in developed countries and also in most of developing countries due to high ozone layer depletion and high global warming potential. But after Montreal Protocol treaty the gas R-22 is to be phased out due to high ozone depletion properties. The developed countries phases out this refrigerant by 2020 and developing by 2030. Now a days we are using R-410A hydro-fluocarbon (HFC) mixture of difluoromethane and pentafluroethane 50%-50% by weight, which is mostly used in industries now a days it has many advantages over R-22 it has no ozone layer depletion but has high global warming potential another eco-friendly refrigerant CO2 which is very cheap as compared to R410A which has low ozone layer depletion and low global warming potential.CO2 has high refrigeration capacity up to 4-5 times than R-410A and also has high heat transfer in evaporator and condenser due to high pressure & density. In this work we are calculating the coefficient of performance, refrigeration effect with different refrigerant under different environment condition and made conclusion that either CO2 would we used as a refrigerant or not.

Key words: C.O.P., Refrigeration effect, R 22, R410A and R 744, Work done

I. Introduction

Refrigeration is used in industry for cooling and freezing of products, condensing vapors, maintaining environmental conditions, and for cold storage. The number of different applications is huge and they are a major consumer of electricity. In some sectors, particularly food, drink, and chemicals it represents a significant proportion of overall site energy costs. Presently, the refrigeration industry urgently needs technical information on the refrigeration systems, system components, and technical and operational aspects of such systems and components, procedures for energy and exergy analyses of refrigeration systems for system design and optimization, application of optimum refrigeration techniques, techniques for the measurement and evaluation of the components' performance; and methodology for the use of the cooling data to design an efficient and effective refrigeration system and/or to improve the existing refrigeration systems.

II. Vapor Compression Refrigeration System

In practical applications, vapor-compression refrigeration systems are the most commonly used refrigeration systems, and each system employs a compressor. In basic vapor-compression refrigeration cycle four major thermal processes take place as follows:

- Evaporation,
- Compression,
- Condensation, and
- Expansion

III. Refrigerants

The refrigerant is heat carrying mediums which during their cycle (i.e. compression, condensation, expansion and evaporation) in the refrigeration system absorbs heat from a low temperature system and dissipates 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, sulphurdioxide, 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.

IV. Methodology

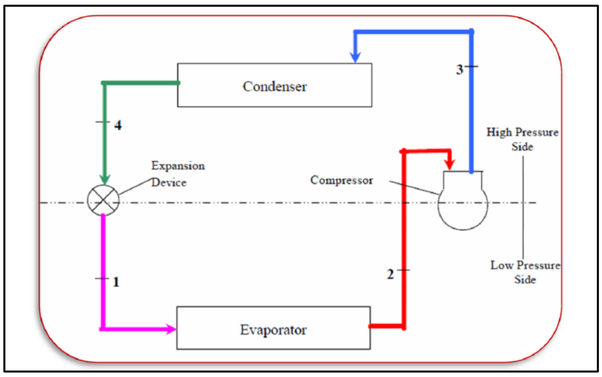


Fig. 1: Schematic diagram of VCR Cycle

The figure shows the schematic block diagram of vapor compression refrigeration cycle in which process 1-2 is isentropic compression in which the pressure and temperature of refrigerant increases in the next process that is in 2-3 there is constant pressure heat rejection, the temperature increases in compressor is above the surrounding temperature so that here in this process 2-3 heat transfer is take place from higher temperature to lower temperature and here the temperature drop takes place to surrounding temperature but the pressure is higher at that level in the next process 3-4 there is isenthalpic expansion in which pressure reduced to initial level, in the final process

4-1 there is constant pressure heat absorption from the surrounding space here refrigerant takes heat from surrounding space and evaporated which is also known as evaporator in case domestic refrigerator.

V. CHARACTERISTIC OF R410A AND PROPOSED CO_2 AS REFRIGERANT

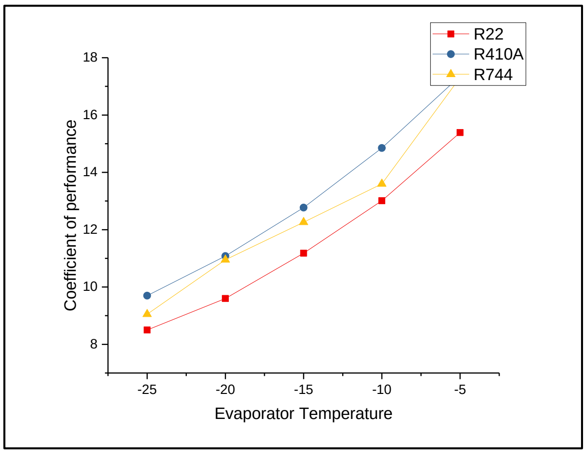
The thermo physical property like molecular mass, normal boiling point, critical temperature, critical pressure, latent heat, global warming potential and ozone layer depilation of different refrigerant is shown below.

Refrigerant / Property	Chlorodifluoromethane R22	Zeotropic blend R410A	Tetrafluoroethane R134a	Natural Refrigerant CO_2 R744
Molecular Mass	86.46	72.6	102.3	44.01
Normal Boiling Point	-41.3	-55.4	-26	-109.4
Critical Temperature(C)	205	162	214	88
Critical Pressure (kPa)	722	690	590	1070
Composition	Difluoromonochloromethane	R-32 + R125 (50%+ 50%)	CH_2FCF_3	Carbon Dioxide
Latent Heat (kJ/kg)	233	275	1444	14592
Ozone Layer Depliction	0.055	0	0	0
Global Warming Potential	1810	3260	1300	1

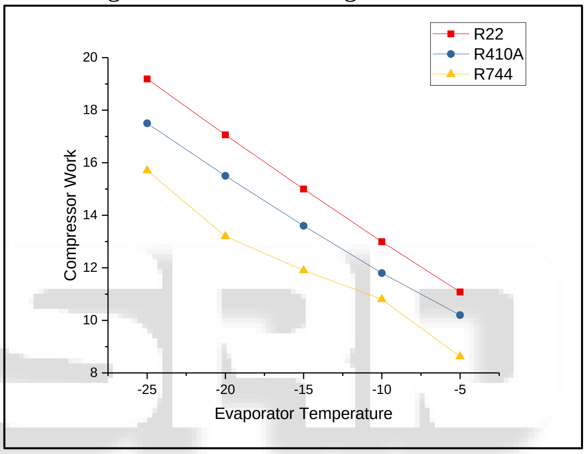
Ozone Depletion Potential (ODP) of a chemical compound is the relative amount of degradation it can cause to the ozone layer. Global Warming Potential (GWP) is a measure of how much a given mass of a gas contributes to global warming. GWP is a relative scale which compares the amount of heat trapped by greenhouse gas to the amount of heat trapped in the same mass of Carbon Dioxide. The GWP of Carbon Dioxide is by definition *1*.

VI. RESULT & DISCUSSION

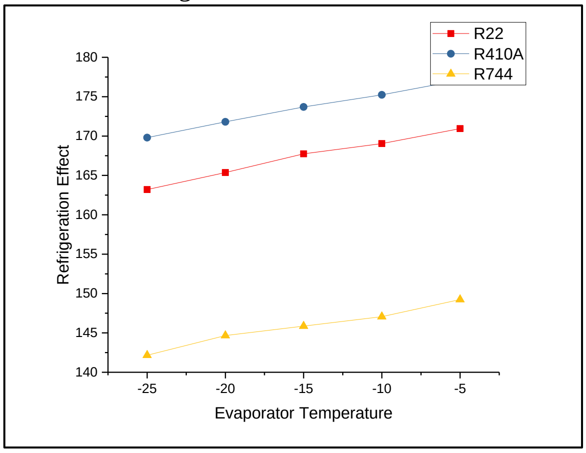
We are calculating the various parameters for refrigerant R22, R410A and for R744 and at various environment conditions and comparison is done on the basis of coefficient of performance of refrigerant, on the basis of refrigeration effect also



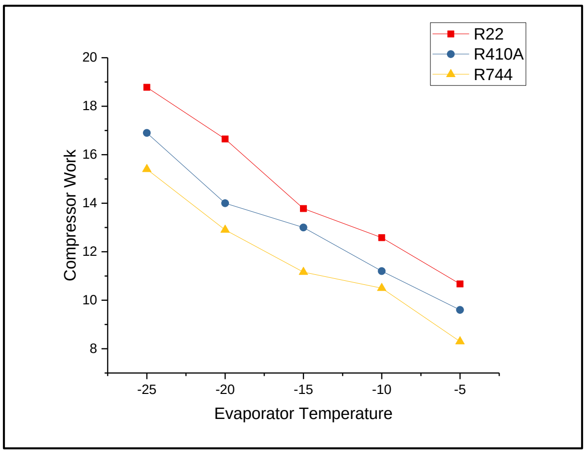
The above graph represents the coefficient of performance of all three refrigerants at different evaporator temperature. From the graph we clearly see that as the temperature is decreasing the coefficient of performance of all three refrigerants start decreasing.



The above graph represents the compressor work at different evaporator temperature. We clearly see that as the evaporator temperature start decreasing the compressor work start increasing.



The above graph shows the refrigeration effect of all refrigerants at different evaporator temperature. From this graph we see that the difference in refrigeration effect is not much high in all three refrigerants



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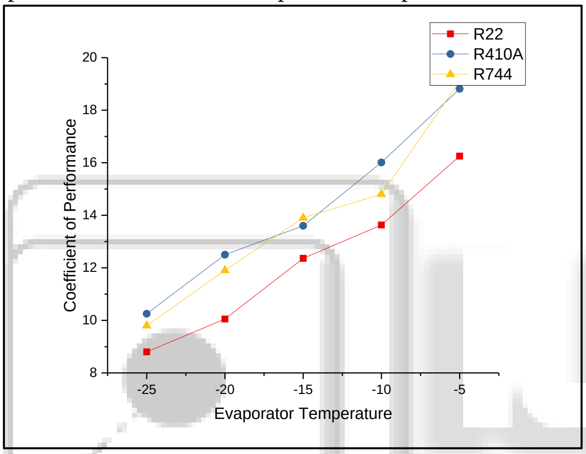

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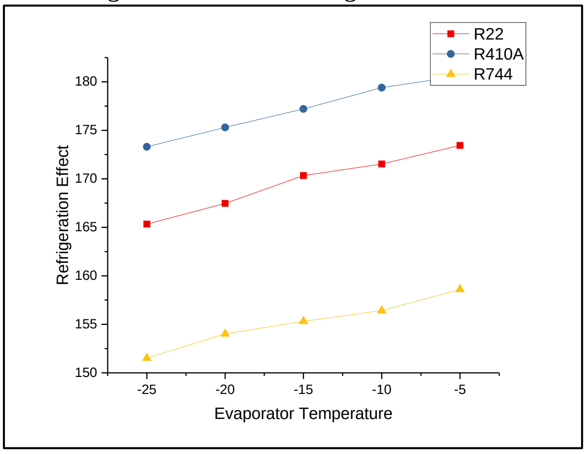

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VII. Conclusion & Future Scope

The parameter that are evaluated in this work are coefficient of performance, compressor work and refrigeration effect. Here in this work three different refrigerant are used for evaluating these parameter they are R22 difluoromonochloromethane, R410A hydro-fluocarbon and R744carbon dioxide. If we see the graph of coefficient of performance of all refrigerants at different evaporator temperature we see that the graph of coefficient of performance of R744 is lie between the graph of R22 and R410A so we can use R744 in place of R410A and in place of R22 as a refrigerant. If we see the graph of compressor work of all refrigerant at different evaporator temperature we see from the graph that the compressor work of R744 is low as compared to R22 and R410A which proves again that we use R744 as a refrigerant.

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