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A Performance of a Window Air Conditioner Using Alternative Refrigerants R22 AND R410A

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Abstract

This paper presents the experimental performance analysis of a window air conditioner using two refrigerants R22 and R410A.The effect of the different parameters of performance analysis (refrigeration capacity, COP, compressor power ,pressure ratio) were investigated for various evaporating temperature and ambient temperature. .The result shows that refrigerant R22 is better than R410A in case of COP, refrigeration capacity but for pressure ratio and compressor power R410A shows better performance than R22.Since R22 refrigerant has better performance than also this refrigerant is replaced by the end of 2015.Due to their severe environmental impact.

NOMENCLATURE:

COP : Coefficient of Performance	ODP: Ozone Depletion Potential
GWP : Global Warming Potential	h : Specific Enthalpy (KJ/KG)
M : Mass Flow Rate	P: Pressure (KPA)
PR : Pressure Ratio	Q :Heat Transfer Rate (KW)
T : Temperature	Th: Thermometer
EER : Energy Efficiency Ratio	HC: Hydrocarbon
HCFC : HydrochloroFluro Carbon	$T_{Cond.}$ CondenserTemperature (K)

Keywords: Window air conditioner, R22 ,R410A, Azeotropic mixture

Introduction

During the last decade , the number of refrigerants used in refrigerating unit has dramatically increase as a consequence of the elimination of the CFC'S and HCFC'S .Recently the ozone depleting potential (ODP) and global warming potential (GWP) have become the most important criteria in the development of new refrigerant apart from the refrigerant CFC's and HCFC's . In spite of the high GWP alternative to refrigerants CFC's and HCFC's such as hydroflurocarbon (HFC) refrigerants with their zero ODP have been preferred for use in many industrial and domestic applications intensively for decades. HFC refrigerant also have suitable specification such as non–flammability, stability and similar vapour pressure to the refrigerant CFC's and HCFC's .R22 is one of the important refrigerants used in air conditioning all over the world. R22 is controlled substance under the montreal protocol. It has to be totally phased out by 2015. In Europe, HCFC's already have been phased out in 2002,and the total phased out of HCFC's is scheduled in 2015. R22 replacement option for air conditioner , heat pump ,and refrigeration system can be grouped in three categories are fluorocarbons ,that are used in conventional vapour compression cycle such as R134a , R410A ,R407C, alternative fluid which include propane R290 and R717and are also used in vapour compression cycle, and finally alternative cycles that include absorption systems and use trans critical fluids (CO_2)and air cycle .In general these alternative technologies do not currently offer the same energy efficiency as the vapour compression cycle.

The HFC refrigerant are considered as one of the fix target green house gases under the Kyoto Protocol Of United Nation Frame Work Convention on climate change (UNFCCC) .In 1997 {31,32} Kyoto Protocol was approved by many nation called for the reduction in emission of green house gas including HFC refrigerants. The presence of fluorine atoms in R134A is responsible for the major environmental impact (GWP) with serious implication for the future development of the refrigeration based industries.

The refrigerant R410A is a near azeotropic blend of R32 and R125 with a critical temperature of 72.8 ^{0}C and a critical pressure of 4.86 MPa. Its ozone

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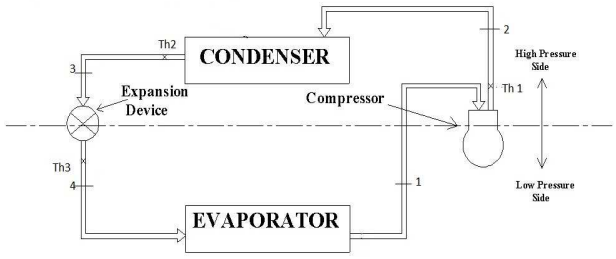
depletion potential is zero and it has been adopted in air conditioning and heat pump system for residential application. R410A has high volumetric cooling capacity ,which means that this refrigerant can absorb significant amount of heat from the air for a unit volume of refrigerant in a direct expansion evaporator. R410A operates at high pressures than R22 and its GWP is 2,088 [33].Several researcher investigated refrigerants that could potentially retrofit R410A in air conditioning system. In India ,about one million room air conditioner (ACs) are manufactured in various capacities every year with refrigerant R22 , which seriously depleted ozone layer and contribute to green house effect . Thesubstitute for refrigerant R22 is R410A because of its close match to R22 in exiting window air conditioner. R410A can be directly used in place of R22 compressor with little modification .Polyol Ester (POE) is to be used with R410A instead of mineral oil.

Experimental Setup

The schematic diagram representing the air conditioner is shown in figures 1, 2 . The unit was retrofitted with R22 and R410A. In order to have a uniform temperature throughout the room , aceiling fan of 60 watt power installed in the centre of room was used to circulate the air inside the room .

To measure compressor power, a multimeter with ±0.5 % accuracy was used.Room temperature was measured with the help of precision thermometer with an accuracy of $\pm 0.01^0$C.The specification of air conditioner test unit is given in table no. 1.



Where: Th: thermometer
Fig 1: Experimental Unit Cycle

FIG:2a –Open Unit **FIG:2b –Closed Unit**
Fig:2-Air Conditioner Experimental Test Unit

Table:1 : Specification Of Air Conditioner Test Unit

COMPRESSOR:	=	Reciporacating Type
FAN:	=	2900 RPM
CAPILLARY:	=	Cu Tube
EVAPORATOR:	=	Cu Coil
TEMPRATURE MEASURING RANGE	=	-50^0C TO 80^0C(accuracy$\pm 1^0$c)
RELATIVE HUMIDITY RANGE	=	20% TO 85%
CAPILLARY LENGTH	=	832 mm
EVAPORATOR:AVG SAT. TEMP.	=	10^0C to 12^0c
CONDENCER:AVG SAT. TEMP.	=	40^0

Performance Parameters Analysis

The equations for the cycle analysis can be obtained by means of mass and energy conservation. The data reduction of the theoretical results can be analysed below. The pressure ratio of the cycle can be seen below as follows:

The pressure ratio = $P_{cond.} / P_{evap.}$

The refrigerating effect (RE), in other words, the heat transfer rate of the evaporator ($Q_{evap.}$) is calculated as follows:

$R_E = Q_{evap} = h_1 - h_4$ kj/kg

Isentropic compression work of the compressor (Wcomp) is expressed as follows:

$W_{comp} = h_2 - h_1$ kj/min

The coefficient of performance (COP) of the refrigeration system's cycle can be determined by:

$COP = R_E / W_{comp}$

Power of refrigeration is calculated as follows:

Power piston of refrigerant = Wcomp/60 kw

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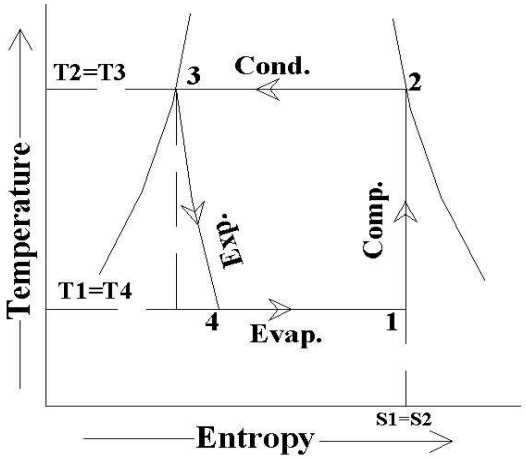
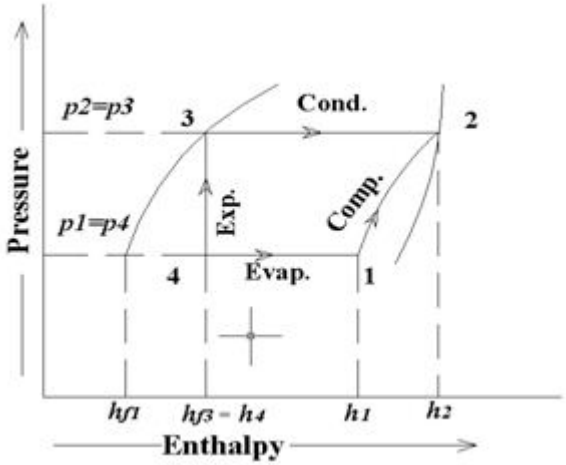


(a) T-s Diagram



(b) p-h Diagram

fig 2:Theoretical vapour Compression Cycle

PROPERTIES	REFRIGERENT	
	R 22	R 410 A
Composition	$CHClF_2$	50+.5,-1.5% CH_2F_2 50+1.5,-.5% C_2HF_5
Critical Temp. (°C)	96.14	70.5
Critical Pressure (kPa)	4990	4770
ODP	0.05	0
GWP(100years)	1810	2100
Boiling Temp.(^{0}C)	-40.8	-51.4
Atm life(yrs)	96.1	18.155
MOLECULER WT. (g/mol)	86.5	72.6

Result and Discussion

R22and its retrofit refrigerant R410Awere used in window air conditioner and system performance were evaluated and compared. The result of the refrigeration capacity obtained at different evaporating temperature is shown in figure:3. Evaporating temperature varied from 2ºC to 12ºC as a result of the variation of the indoor temperature from 17ºCto 26ºC using the system temperature control.It was observed that for all the investigated refrigerants, the refrigeration capacity increased with increase in evaporating temperature. At the sametime, evaporating temperature for refrigeration capacity obtained with the R22 system is higher than that from the R410A system. Average refrigeration capacity of R410A is 14.1% lower than that with R22.

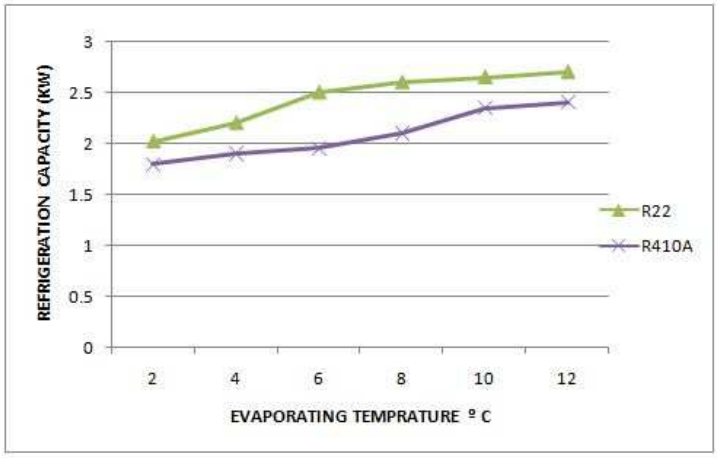


Figure 3: Variation of refrigeration capacity with evaporating temperature

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Figure:4 Shows the variation between the compressor power and the evaporating temperature of R22 and the alternative refrigerantsR410A. As shown in figure, thechange of compressor power with evaporating temperature is similar for both the refrigerants.As the evaporating temperature is increase the compressor power also increases. The compressor power with R410A is higher than those with R22 .The average compressor power with R410A increased by 11%.as compared with R22.

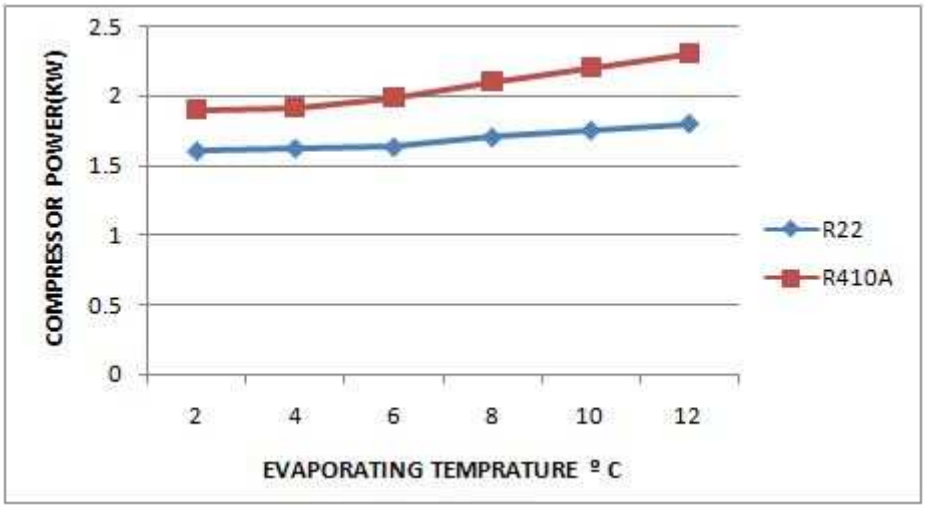

Figure 4: Variation of compressor powercapacity with evaporating temperature

The performances of investigated refrigerants in window air conditioner were obtained for different ambient air temperature. The ambient air temperature varied from 25ºC in the early hours of day to 40ºC in the late afternoon. The refrigeration capacity and COP obtained with R22 and R410A at various ambient temperature is plotted in figure:6 and figure:7. As shown in these figures, the refrigeration capacity and COP reduce as ambient air temperature increase. Also it can be seen from these figures, that the performance with R22 is better than R410A.

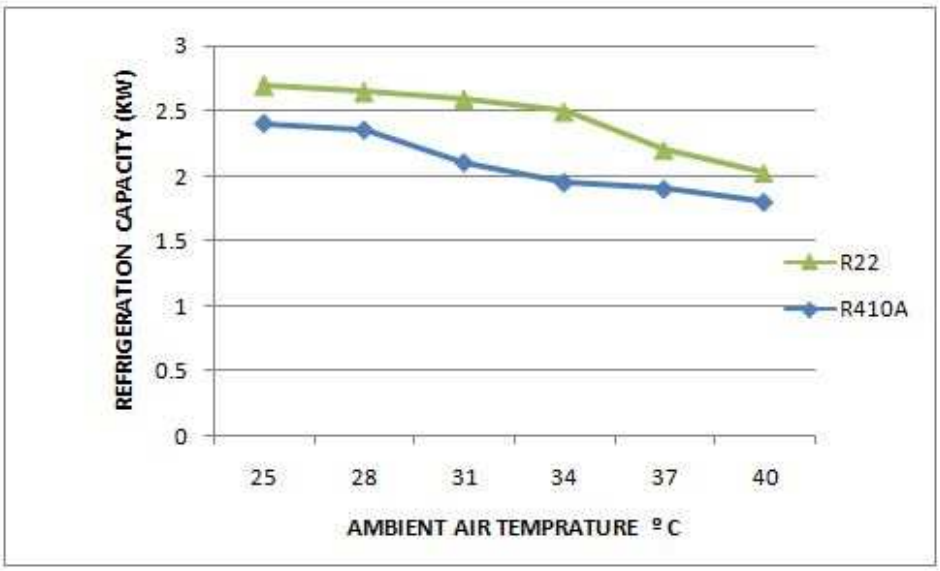

Figure 6 :Effect of ambient air temperature on the refrigeration capacity

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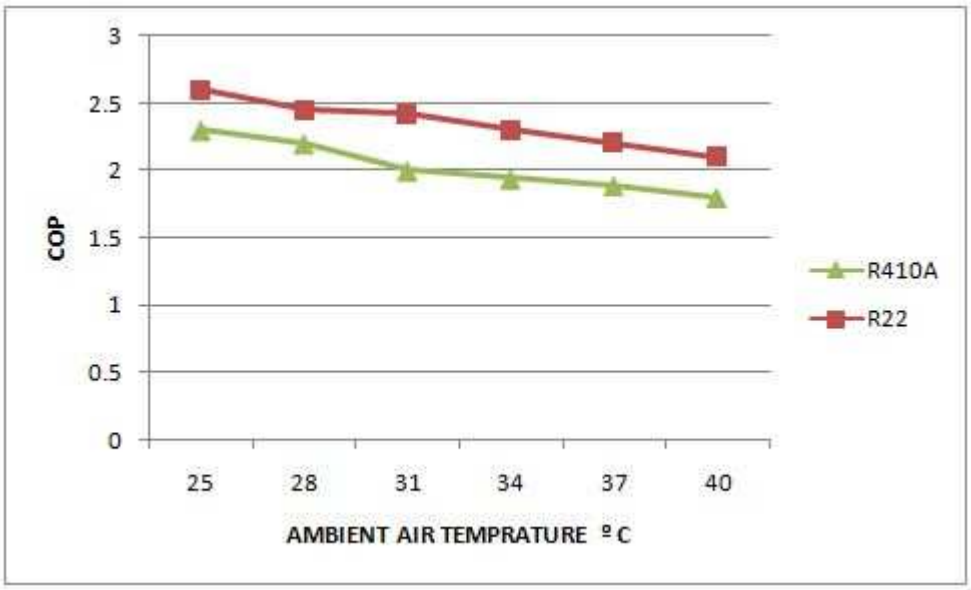

Figure 7: Effect of ambient air temperature on the coefficient of performance (COP)

Figure:8 Compare the variation of compressor power for the two refrigerants in terms of ambient temperature as shown in these figures. The compressor power increase as the ambient temperature increases but there is considerable difference in the performance with R22 and R410A. The compressor power with R410A were found to be highest among the R22 refrigerant at all ambient air temperature.

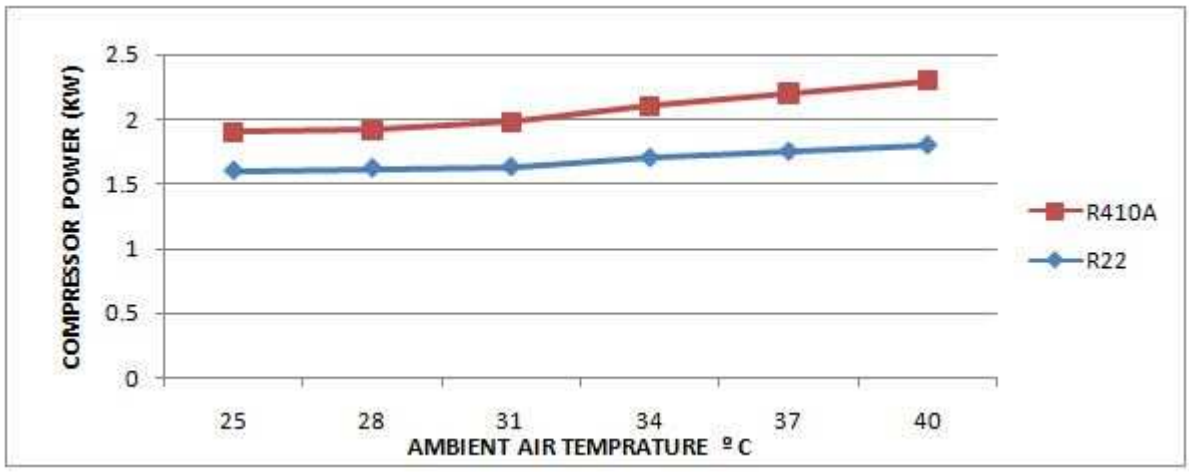

Figure 8: Effect of ambient air temperature on the compressor power

Figure:9compare the variation of pressure ratio for the two refrigerants in terms of ambient temperature as shown in these figures. The pressure ratio increase as the ambient temperature increases but there is considerable difference in the performance with R22 and R410A. The pressure ratio with R410A were found to be highest among the R22 refrigerant at all ambient air temperature.

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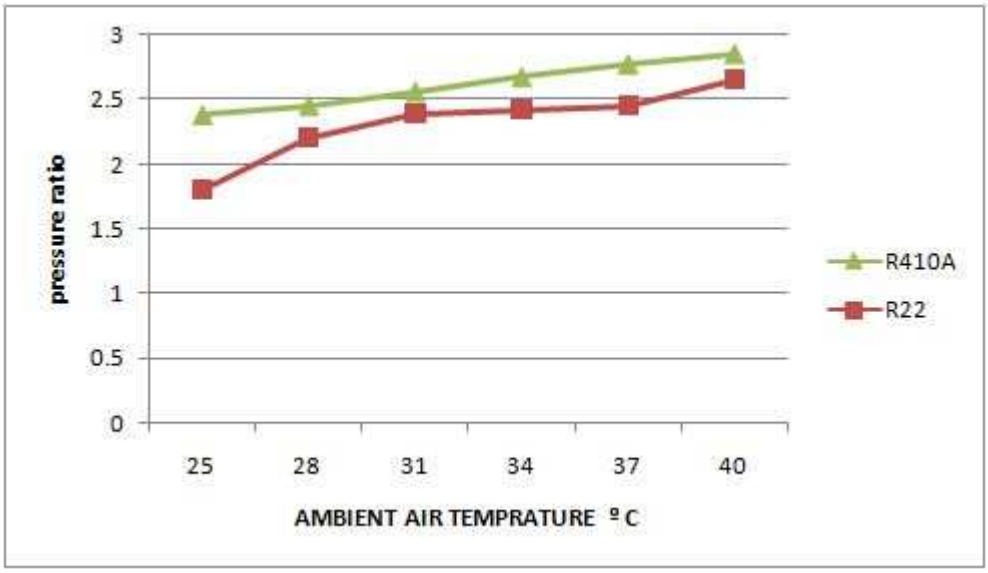

Figure 9: Effect of ambient air temperature on the pressure ratio

Conclusions

In this study, experiments were carried out to investigate R22 and its retrofit substitute R410A in a window air conditioner. Based upon experimental result, the following conclusions were drawn

1. The refrigerant capacity and COP reduce and compressor power and pressure ratio increase in case of R410A.
2. The performance parametersi.e. refrigeration capacity, COP increases with increase in evaporating temperature in case of R22.
3. The compressor power of R410A is higher than R22.
4. The average COP of R410 is lower than the R22.

Finally, the system when charge with R22 consistently had the best performance when compared with system containing R410A. But then also the refrigerant R22 is replaced by R410A because of its high ozone depletion which severeaffects our environment. R410A is zero ozone depletion and high volumetric cooling capacity. R410A refrigerant operates at high pressure then R22.

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