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Experimental Study on the Performance of a Window Air Conditioner Using R22 and R290

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ABSTRACT

In this paper, simulation studies of a one TR window air conditioner were carried out with three different mixtures of R22 and R290 M1 (50-50) %, M2 (25-75) % and M3 (75-25) %. Performance parameters like refrigerant mass flow rate, refrigerant capacity, compressor power, C.O.P, condenser inlet temperature, condenser outlet temperature, capillary tube inlet temperature and compressor shell inlet temperature were analyzed at varying conditions, evaporator temperature varied from 60C to120C and condenser temperature varied from 400C to 550C and results were analyzed. Performance parameters of R22 and R290 are compared using CYCLE _D software. Simulation results show that R290 has a maximum mass flow rate. Only a marginal variation of capacity is observed with all working fluids. The condenser inlet temperature is minimum for R290 and maximum for R22. Condenser outlet temperature variation is marginal for all refrigerants. R290 has a minimum power consumption and maximum C.O.P. The simulation results show that the use of hydrocarbon refrigerant (R290) improves the performance of window air conditioner.

KEYWORDS: Window air conditioner, R22, R290.

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 (CO2)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 and Commercial
chlorofluorocarbons (CFCs) are recognized for their severe harmful effects on the environment when they are released to the atmosphere. Specific concerns about their use in air conditioning and refrigeration equipment are related to their potential contribution to global warming and their depletion effect on the stratospheric ozone layer due to their chlorine chemical effect. Due to the fact that CFCs damage the ozone layer, environmental groups and the Montréal protocol call for halting CFC production. Thus alternative refrigerants must be found to replace the CFC Such alternative refrigerants should possess good thermo dynamical and physical properties, comparable cost, low toxicity and low inflammability hydrocarbon offers acceptable refrigerants to the CFCs, since they posses good thermo dynamical properties and they are universally available at low price. The absence

of chlorine atoms from hydrocarbons results in zero ozone layer depletion potential is very low for hydrocarbons, owing to their higher latent heat of hydrocarbons compared with that of R-22. The thermodynamics properties of R290, R22 are shown in table

Table.1 Thermodynamics properties of refrigerants

Refrigerant	Boiling point (^{0}C)	Freezing point (^{0}C)	Critical temperature (^{0}C)	Latent heat (kJ/kg)
R-290	-42.1	-97	97	423.3
R22	-41	-160	96.2	216.5

1.1 R 290(propane)

Refrigerant R 290, or propane, is a possible replacement for other refrigerants, which have high impact on environment, in small hermetic systems, like factory made commercial refrigerators and freezers. It has zero ozone depletion potential ODP and a neglectible global warming potential GWP. Furthermore it is a substance which is a part of petrol gases from natural sources. The refrigerant R 290 has been in use in refrigeration plants in the past, and is still used in some industrial plants. In domestic heat pumps and air conditioners R 290 has been used in Germany for some years, however, with different level of success. Because of the availability of propane all over the world it has been discussed widely for CFC replacement. Propane R 290 is a possible refrigerant for this application, with good energy efficiency, but special care has to be taken to the flammability of propane

1.1.1 REFRIGERANT CHARGE

If R 290 would be charged into an unchanged refrigeration system, charge amount counted in grams would be much lower. However, calculated in cm^3, the charge would be roughly the same liquid volume in the system. This gives charges of approx. 40 % of R 22 or R 404A charge in grams, according to the data from table 1, which also corresponds with empirical values. Maximum charge according to safety regulations is 150 g for household refrigerators and similar applications, which corresponds to approx. 360 g of R 22 or R 404A.

1.1.2 PURITY

Refrigerant R 290 specification is not found in international standards. Some data are enclosed in the German standard DIN 8960 of 1998, which is an extended version of ISO 916. The purity of the refrigerant has to be judged from chemical and stability side, for compressor and system lifetime, and from thermodynamic side regarding refrigeration system behaviour and controllability. The specification in DIN 8960 is a safe general hydrocarbons refrigerant specification, adopted from other refrigerants criteria catalogue and covering propane, isobutane, normal butane, and others. Some points can possibly be accepted a little less narrow for specific refrigerants and impurities combinations after extensive evaluation. For the time being no refrigerant quality according to an official standard is on the market. The specifications of possible qualities have to be checked with the supplier in details. Liquified petrol gas LPG for fuel applications or technical grade 95 % purity is not sufficient for hermetic refrigeration. Water, sulfur and reactive compounds contents has to be on a lower level than guaranteed for those products. Technical grade 99.5 %, also called 2.5, is widely used.

1.2 R-22(Chlorodifluoromethane)

Chlorodifluoromethane or difluoromonochloromethane is a hydrochlorofluorocarbon (HCFC). This colorless gas is better known as HCFC-22, R-22. It was once commonly used as a propellant and in air conditioning applications. These applications are being phased out due to ozone depletion potential and status as a potent greenhouse gas. R22 is a versatile intermediate in industrial organofluorine chemistry, e.g. as a precursor to tetrafluoroethylene.

1.2.1 ENVIRONMENTAL EFFECTS

Chlorodifluoromethane was used as an alternative to the highly ozone-depleting CFC-11 and CFC-12, because of its relatively low ozone depletion potential of 0.055, among the lowest for chlorine-containing haloalkanes. However, even this lower ozone depletion potential is no longer considered acceptable. It will be phased out soon under the Montreal Protocol, to be replaced by other refrigerants with lower ozone depletion potential such as propane (R-290), R-410A (an azeotropic mixture of difluoromethane and pentafluoroethane), R-507A, R-134a (1,1,1,2-tetrafluroethane) and R-409A.

As an additional environmental concern, chlorodifluoromethane has a global warming potential that is 1700 (1700 times that of carbon dioxide). HFCs such as R-410A have high global warming potential, whereas that of propane (R-290) is only 3.

2 REFRIGERANT CHOSEN

Air conditioning has to use refrigerants and although there are many types of refrigerants, including air and water, it is necessary to use chemicals for reasons of efficiency and ultimately to conserve energy.

1) R22 is a single hydro chlorofluorocarbon or HCFC compound. It has low chlorine content and ozone depletion potential and only a modest global warming potential. R22 can still be used in small heat pump systems, but no more new systems can be manufactured for use in the EU after late 2003. From 2010 only recycled or saved stocks of R22 can be used, as it will no longer be manufactured. - ODP = 0.05, GWP = 1700

2) R290 - Pure propane, a hydrocarbon (HC) an efficient naturally occurring refrigerant with similar properties to R22, but no ozone depletion potential and an extremely low global warming potential. Whilst it is environmentally safe, it is also highly flammable and must only be used after careful consideration is given to safety. - ODP = 0, GWP = 3

The window air conditioner used in the present work has a capacity of a one TR and it is designed to work with traditional refrigerant R22, alternative refrigerant R290. The mass of refrigerant charge is 1 kg. The refrigerant data includes selection of refrigerant and weight composition. The performance parameters are compressor isentropic efficiency of 0.5, volumetric efficiency of 0.8, motor efficiency of 0.7, evaporator temperature varied from 6oC to 120C, condenser temperature varied from 40oC to 550C, superheat at evaporator exit temperature are 110C and 30C, sub cooled at condenser exit temperature are 8.30C and 00C and heat exchanger effectiveness of 0.3 are given in cycle data and analyzed using CYCLE _D software. Thermodynamic cycle results and compressor results are obtained. The performance results are plotted against evaporator and condenser temperature corresponding to a few points or the COP of the system. These both values are necessary for the proper evaluation of the refrigerant mixtures and the cooling system.

RESULTS AND DISCUSSTION

R22and its retrofit refrigerant R290 were used in window air conditioner and system performance were evaluated and compared. It is clear that R290 is the best performing refrigerant among the unmixed refrigerants. But R290 is highly flammable. It was observed that for all the investigated refrigerants, the refrigeration capacity increased with increase in evaporating temperature. At the same time, evaporating temperature for refrigeration capacity obtained with the R290 system is higher than that from the R22 system.

REFRIGERATION MASS FLOW RATE

The mass flow rate variation for refrigerant mixture R22 and R290 with three different mixture are shown in fig 1 at the condenser temperature maintain at 500C and evaporator temperature varied from 60C to 120C the refrigerant mixture increases the mass flow rate of R290 in the range of (3.6% - 4.1%). When the evaporator temperature maintain constant at 80C and condenser temperature varied from 400C to 550C. the mass flow rate increases in the range of (3.7% - 4.2%).

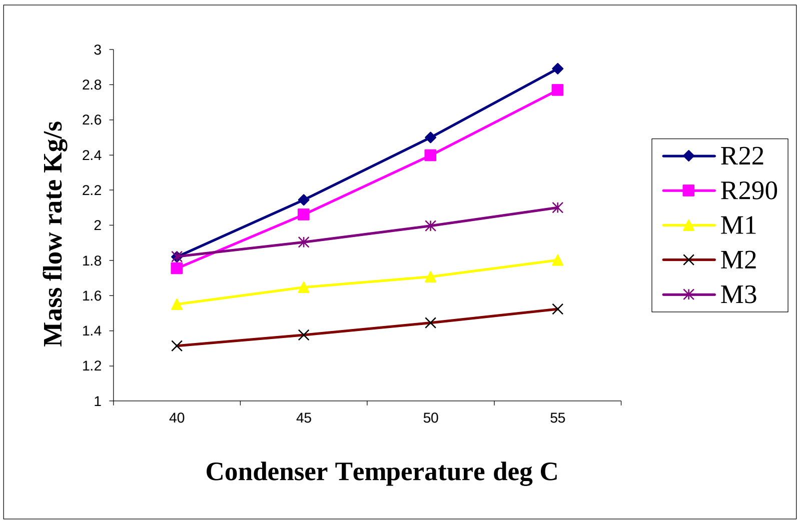

Fig 1 Variation of mass flow rate with condenser temperature

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3.1 HEATING CAPACITY

The variation of heating capacity at varying condenser temperature and varying evaporator temperature are shown in fig 2.Heating capacity shows a marginal variation (0.4%-0.7%).

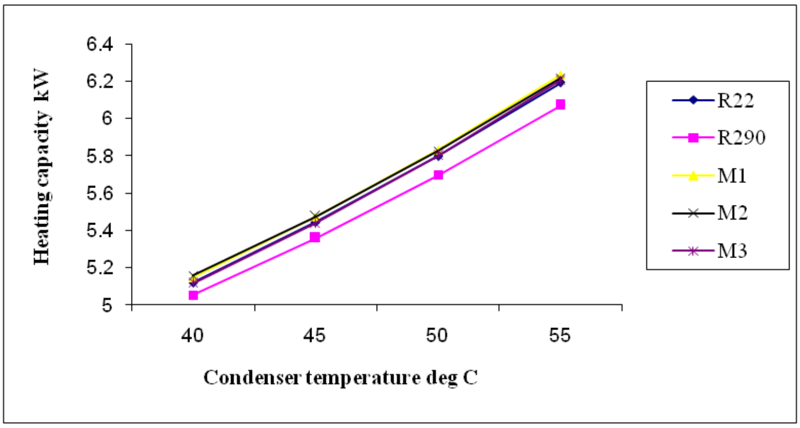

Fig 2 Variation of heating capacity with condenser temperature

3.2 CONDENSER INLET TEMPERATURE

Fig 3, show the variation of condenser inlet temperature for R290 refrigerant mixture at varying condenser temperature and varying evaporator temperature from Fig show that condenser inlet temperature maximum for R22 and minimum for R290.comparing R290, R22 shows a better performance in term of condenser inlet temperature (compressor exit temperature).

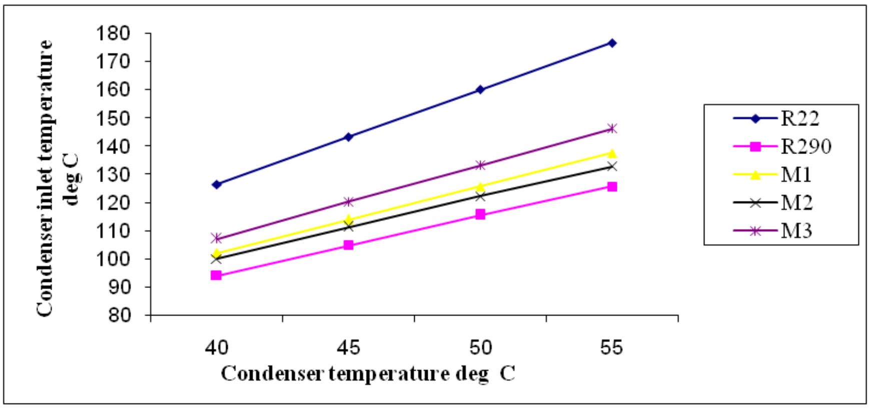

Fig 3 Variation of condenser inlet temperature with condenser temperature

3.3 COMPRESSOR POWER

The compressor power found to be increases in the range of (4.3%-4.6%)for R290 as shown in fig 4 at varying condenser temperature and fig 16 at varying evaporator temperature power decreases in range of(4.3% - 4.7%). By comparing R22 with R290 refrigerant R290 show a better performance.

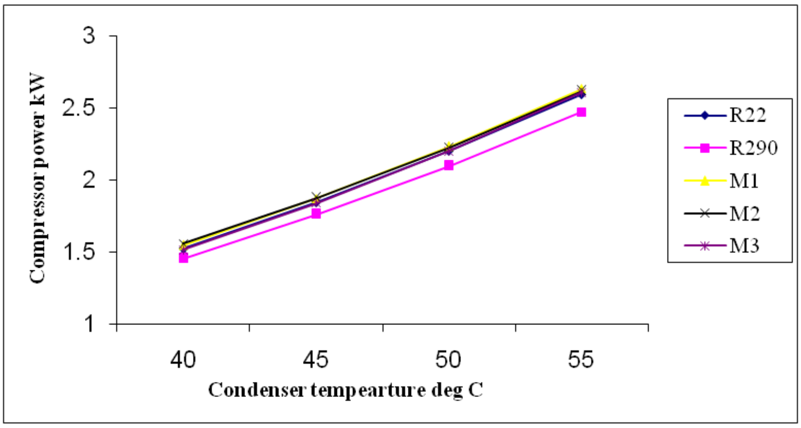

Fig 4 Variation of compressor power with condenser temperature

3.4 COP

In R290 added in the present study is found to improve the co-efficient of performance of the air conditioning system, the improvement of COP in the system is in the range of (4.5%-5.0%).

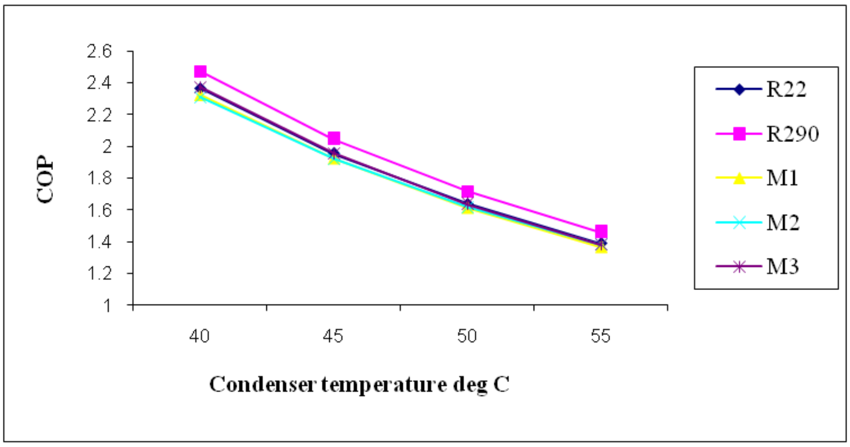

Fig 5Variation of COP with condenser temperature

CONCLUSIONS

Mixed refrigerant is used in small window air conditioner, co-efficient of performance and mass flow rate are found to be increased. On the other hand the power consumed by compressor is reduced. The simulation result shows that the use hydrocarbon refrigerant (R290) improves the performance of window air conditioners.

In this study, experiments were carried out to investigate R22 and its retrofit substitute R290A 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 R290.
2. The performance parameters i.e. Refrigeration capacity, COP increases with increase in evaporating temperature in case of R290.
3. The compressor power of R290 is higher than R22.
4. The average COP of R290 is lower than the R22.

Finally, the system when charge with R290 consistently had the best performance when compared with system containing R22. But then also the refrigerant R22 is replaced by R290 because of its high ozone depletion which severe affects our environment. R290 is zero ozone depletion and high volumetric cooling capacity. R290 refrigerant operates at high Pressure then R22

REFERENCES

1. M. PAULUS- LANCKRIET, O. BUYLE, R407C/R410A :an analysis of the two prominent candidate for the replacement of R22 in refrigeration application ,in proceeding of IIF–IIR conference , Linz ,Austria ,1997, PP 85-93.
2. D LEE .VAHNA,Y.KIM ,Y.CHANGA,L.NAM, Experimental investigation on the drop in performance of R407C as a substitute for R22 in a screw chillier with shell and tube heat exchanger .International journal of refrigeration 25(2001) 575-585.
3. C.APREA, AGRECO: An experimental evolution of the green house effect in R22 substitution, Energy conversion and management 39(1998) 877-887.
4. C.APREA, A.GRECO,: An exegetic analysis of R22 substitution ,Applied thermal engg. 22 (2002) 1455-1469.
5. C.APREA, A GRECO, Performance evolution of R22 and R407c in a vapour compression , Applied Thermal Engg. 23 (2003) 215-227.
6. R.CABELLA, E.TORRELLA, J. NAVARRO – ESBRI, Experimental evolution of a vapour compression plant performance using R134A, R407C and R22 as working fluids ,Applied Thermal Engg. 24 (2004) 1905-1917.
7. S.DEVOTTA , AS PADALKAR , N.K.SANE ,Performance assessment of HCFC 22 window air conditioner retrofitted with R407 C ,Applied Thermal Engg . 25 (2005) 2937 -2949.
8. H. KONG, Comparison of R410a , R407c and propane in heat pump application in proceeding of IIF-IIR conference ,Linz Austria 1997 ,PP 94-103.
9. M.W.SPATZ ,Y.MOTTA , AN evolution of option for replacing HCFC-22 in medium temperature refrigeration systems , International Journal of Refrigeration 27 (2004) 475-483.

10. M.O. McLinden and R. Radermacher, Methods for comparing the performance of pure and mixed refrigerants in the vapor compression cycle. Int. J. of Refrigeration 10 (1987), pp. 318–325.
11. H. Ross, R. Radermacher, M. DI Marzo and D. Didion, Horizontal flow boiling of pure and mixed refrigerants. Int. J. Heat Mass Transfer 30 (1987), pp. 979–992.
12. E. Granryd and J.C. Conklin, Thermal performance analysis for heat exchangers using nonazeotropic refrigerant mixtures. Heat Transfer in Advanced Energy Systems, ASME Winter Ann. Mtg. 151 (1990), pp. 25–32.
13. M. Chwalowski, D.A. Didion and P.A. Domanski, Verification of evaporator computer models and analysis of performance of an evaporator coil. ASHRAE Trans. 23 1 (1989), pp. 1229–1236.
14. Domanski PA. An evaporator simulation model accounting for refrigerant and one-dimensional air distribution. NISTIR 89-4133, 1989.
15. Lee JH. A development of a computer simulation code for the analysis of multi-path evaporator used in air conditioners. Master thesis, Pohang University of Science and Technology, 1994

