World Applied Sciences Journal 29 (11): 1468-1472, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.29.11.1706

An Experimental Investigation and Performance Evaluation of 1.5 TR Window Air-Conditioner by Using R22, R407C and R410A by Varying the Capillary Pitch

[1]K. John Samuel, [2]K. Govindarajulu and [1]G. Edison,

[1]SMBS Vit University, Vellore Tamilnadu-632014
[2]Department of Mechanical Engineering Jntua, Anantapur-515002, India

Abstract: Due to ecological problems like Ozone depletion and Global warming certain refrigerants like R-22 have to be replaced. HCFC's (Hydro Chloro fluoro carbon) have been identified as the prime foremost cause of Ozone depletion. Driven by 1992 amendment to the Montreal-Protocol that calls for the phase out of HCFC's. HFC's (Hydro fluoro carbon) are substantially less damaging to the Ozone layer than HCFC's. Several refrigerants have emerged as substitutes to replace R-22, the most widely used Fluoro carbon refrigerant in the world. These include the environmentally friendly hydro carbon refrigerants such as R134a, R410A, R407A and R407C. *In* this present work problem of R-22 phase out in air conditioning application is addressed. The main objective of the project is Performance analysis of an window air conditioning system by using three refrigerants like R-22, R407C and R410A with different capillary pitches. *In* view of this it is proposed to carry out a number of experiments on window air conditioner of capacity 1.5 TR using R22, R407C and R410A by varying the capillary pitch. Further it is proposed to make a detailed analysis and comparison of the performance of these refrigerants at various pitches for an window air conditioner. *From* the results it is evident that the refrigerant with R410A with a capillary pitch of 18mm gave the best Coefficient of performance to retrofit an window air conditioner working on R22.

Key words: Air conditioning · Window air conditioner · Ozone depletion · R22 · R407C and R410A · Performance parameters

INTRODUCTION

Since their development in 1931, chloro fluoro carbons (CFCs) were thought to be ideal Refrigerants. They had chemical stability and relatively low toxicity, making them safe both residential and industrial use. In 1974, CFCs were tentatively identified as destructive to the ozone layer, [1]. For the next decade, this relationship was investigated by the World Meteorological Organization and the United Nations Environment Programme (WMO/UNEP) in 1985. The Montreal Protocol (1987), which was agreed to by nearly one hundred and fifty countries, froze CFC consumption in 1989 and pledged to cut it in half by 1998. With CFCs scheduled to be phased out, hydro chloro fluoro carbons (most notably HCFC-22) gained in popularity. Furthermore, the ozone depletion (ODP) of R-22 is only 5.5, [2]. HCFCs and HCFC mixtures were developed that could serve as drop-in replacements for most of the CFCs in use.

Once again replacement of refrigerants needs to be found but this time there are no obvious solutions. While some single-component refrigerants present reduced performance possibilities the solution appears to lie with synthetic mixtures, These mixtures may be azeotropic, near-azeotropic, [3]. A number of the potential alternatives to HCFCs (HFCs and HFC blends) have higher global warming potentials than HCFCs and their use therefore entails a rise in the direct global warming impact of a system, assuming that leakage rates remain the same. Several capillary tubes with different length and inner diameter are tested as test sections, [4]. The analysis of the overall environmental impact of HCFC phase-out decisions is therefore relatively complex and this means

Corresponding Author: K. John Samuel, SMBS Vit University, Vellore Tamilnadu-632014, India.
Cell: +917373115998; +918686722424.

that no universal solution can be right for all situations or operating conditions. It is therefore improvement that, when developing HCFC phase-out strategies, full account be taken of both environmental impacts.

M.A. Akintunde investigated the effects of various geometries of capillary tubes based on the coil diameters and lengths alone, with no particular attention placed on the effect of coil pitch. But the present paper experimented different serpentine capillary pitches to know the performance parameters [5].

A.S. Raut retrofitted capillary tube in refrigeration appliances. Modifications in the capillary tube dimensions are made in the refrigeration system. The present work is also focused on retrofitting R-22 system with better refrigerant having better performance characteristics [1].

MATERIALS AND METHODS

The following procedure is adopted for experimental setup of the Air conditioning system:

- The Air conditioner is selected, working on vapor compression refrigeration system.
- Pressure and temperature gauges are installed at each entry and exit of the components.
- Flushing of the system is done by pressurized nitrogen gas.
- R22 refrigerant is charged in to the vapour compression refrigeration system by the following process:

The systematic line diagram for charging is shown in the fig. 1 it is necessary to remove the air from the refrigeration unit before charging. First the valve V_2 is closed and pressure gauge P_2, vacuum gauge V are fitted as shown in the fig. the valve V_5 is also closed and valves V_1, V_4, V_6 and V_3 are opened and the motor is started thus the air from the condenser receiver and evaporator is sucked through the valve V_1 and it is discharged in to atmosphere through the valve V_6 after compressing it in the compressor the vacuum gauge V indicates sufficiently low vacuum when most of the air is removed in the system. The vacuum reading should be at least 74 to 75 cm of Hg. If the vacuum is retained per above an hour it may be concluded that the system is free from the air. After removing the air the compressor is stopped and valves V_1 and V_6 are closed, the valves V_5, V_2 and V_7 of the refrigerant cylinder are opened and then the compressor is started whenever the sufficient quantity of refrigerant is taken in to the system which will be noted in the pressure gauges. The compressor is stopped. The valves V_7 and V_5 are closed and valve V_1 is opened the refrigerant cylinder is disconnected from the system the pressure gauge is used to note the pressure during the charging the system.

- Leakage tests are done by using soap solution, In order to further test the condenser and evaporator pressure and check purging daily for 12 hours and found that there is no leakages which required the absolutely the present investigation to carry out further experiment.

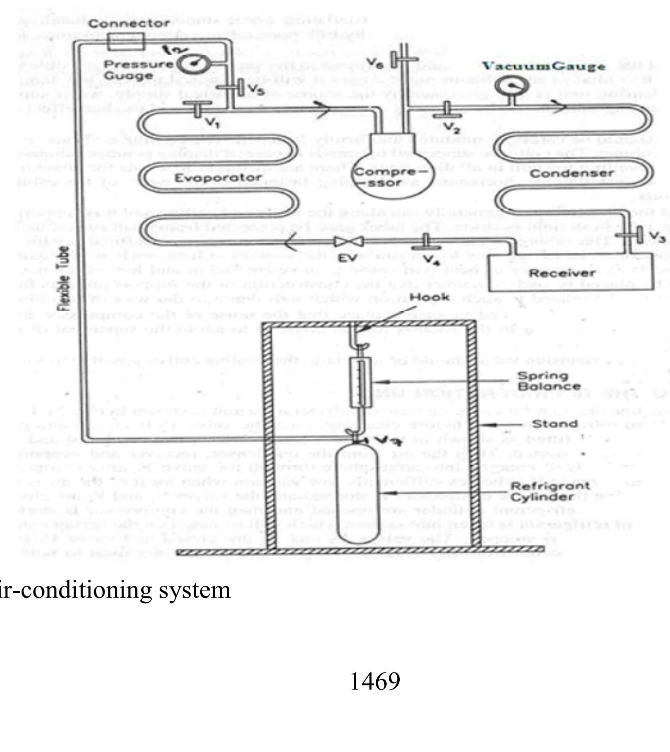

Fig. 1: Charging of an air-conditioning system

Fig. 2: Schematic diagram of serpentine capillary tube

Fig. 3: Schematic diagram of Experimental apparatus

- Switch on the Air conditioner and observation is required for 1 hour and take the pressure and temperature readings at each section.
- The performance of the existing system i.e., running on R22 is investigated, with the help of temperature and pressure gauge readings.
- The refrigerant R22 is discharged out and another refrigerant i.e., R407C is charged into the system and again the performance parameter are calculated at various geometries of serpentine capillary pitch.
- After that the R407C is discharged out and R410A is charged and performance parameters are calculated at various geometries of serpentine capillary pitch.
- Temperature and pressure gauge readings are taken and the performance is investigated.

Experimental Set-Up: In vapor compression refrigeration cycle expansion of refrigerant from condenser pressure to evaporator pressure takes place in capillary tube. In the present experiment, it is proposed to incorporate a serpentine capillary tube with various pitch geometries.

The following Steps involved in the present experimental work

- Bending the Serpentine capillary to the required pitch.
- Incorporating the capillary tube into the system.
- Analysis of the system performance and calculations.

Bending the Serpentine Capillary: Capillary is a passive device which decreases the pressure energy by converting the available kinetic energy at the inlet.

As the velocity of refrigerant is subsonic in the vapor compression refrigeration system the capillary tube is manufactured in comparison with helical capillary dimensions.

Incorporating the Capillary Tube into the System: Experimental Apparatus: The straight capillary which is bent into the required height and pitch is made to fit into the air conditioning system.

RESULTS AND DISCUSSIONS

From the above calculations we can observe that the performance of Air conditioning system of capacity 1.5 Tones has been evaluated experimentally with R22, R407C and R410A. It can be stated that the Performance parameters such as Refrigerant effect, Refrigerant mass flow rate, compressor power, Heat rejection ratio and COP are found.

The figure 4 is the plot of C.O.P of the system with respect to the Refrigerants R22, R407C and R410A at various geometries of serpentine capillary pitch. The figure indicates that the C.O.P values of three refrigerants are increasing up to 18mm and after that they are decreasing. When these three refrigerants C.O.P's are compared it is true that the C.O.P of R22 at 18mm pitch is higher among all other values. But this experimental work is concerned in retrofitting for R22. So if the C.O.P's of R22 are excluded further best C.O.P of the system is for R410A at 18mm pitch.

The figure 5 is the plot of compressor power with respect to the Refrigerants R22, R407C and R410A at various geometries of serpentine capillary pitch. The figure indicates that the compressor power needed to run the air conditioning system is higher for r407C and much lower value for R22.

The figure 6 is the plot of heat rejection ratio with respect to the refrigerants R22, R407C and R410A at various geometries of serpentine capillary pitch. The figure indicates that the values of Heat rejection ratio for all these three refrigerants are almost same.

The figure 7 is the plot of Compression ratio with respect to the refrigerants R22, R407C and R410A at various geometries of serpentine capillary pitch. The figure indicates that when the values of compression ratio of these refrigerants are compared then the compression ratio is high for R407C, intermittent for R22 and lower value for R410A.

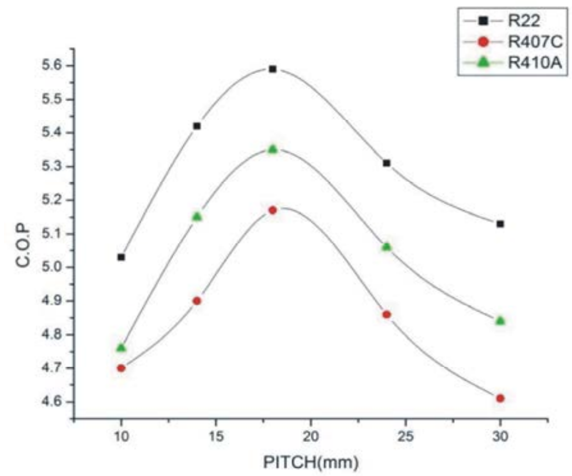

Fig. 4:

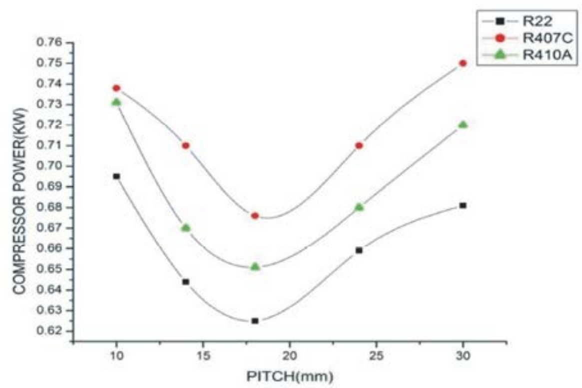

Fig. 5:

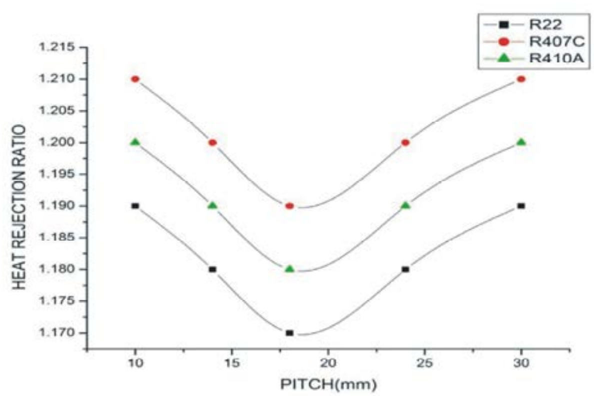

Fig. 6:

The figure 8 is the plot of Mass flow rate of the refrigerant with respect to the refrigerants R22, R407C and R410A at various geometries of serpentine capillary pitch. The figure indicates that the mass flow rate of the refrigerant is high for R407C, intermittent for R22 and least for R410A.

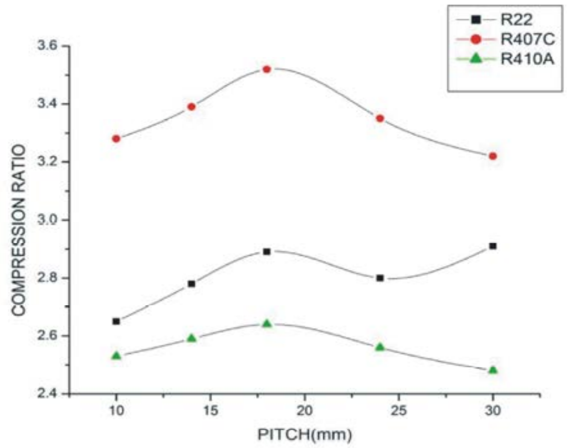

Fig. 7:

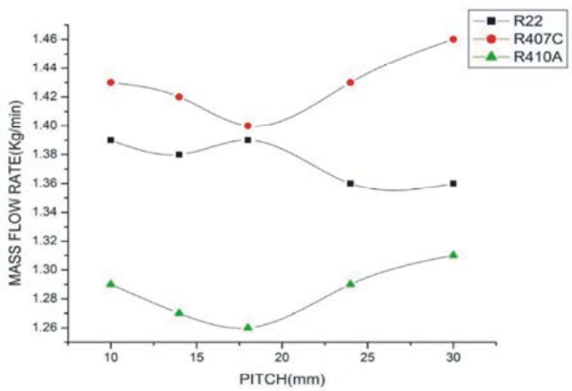

Fig. 8:

CONCLUSIONS

From the experimental analysis it can be concluded that the Refrigerants R22, R407C and R410A were tested on a window air conditioning system of capacity 1.5 Tones at room temperature at National Refrigeration. At this standard condition the important parameters suction pressure, discharge pressure and Evaporator temperature; Condenser pressures are measured for R22 and R407C and R410A.

From the above results the performance parameters are concluded below.

Compressor Power: The compressor power required per ton to drive the system is higher for R407C and little higher for R410A when compared with R22 taken on average basis.

Heat Rejection Ratio: The Heat Rejection Ratio of the system is almost same for all these three refrigerants.

Compressor Ratio: Compressor ratio is higher for R407C when compared with R22 and lesser for R410A when compared with R22 taken on average basis.

Refrigerant Mass flow Rate: The refrigerant mass flow rate per ton is less for R410A when compared with R22, but whereas for R407C it is higher, taken the average of 5 readings.

COP: The Co-efficient of performance of the system for R407C and R410A is less when compared with R22, but the present work is based on retrofitting a refrigerant for R22 because of environmental issues so R410A at 18 mm pitch is the next better performance in the system.

From the above compared performance parameters for three refrigerants i.e, R22, R407C and R410A with different geometries of pitch, Finally it can be concluded that R410A is a better substitute to R22 than R407C with a capillary pitch of 18 mm to retrofit an window air-conditioning system.

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