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EXPERIMENTAL PERFORMANCE OF AIR CONDITIONER USING REFRIGERANT R410 AS ALTERNATIVE FOR R22

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Abstract

Air conditioner is becoming necessary in India as the temperature during normal days and it is become necessity not luxury thing. Most of refrigerants used in vapor Compression system were Chlorofluorocarbon (CFCs) and Hydro Chlorofluorocarbon (HCFCs) which contains chlorine and if any leakage in the system, these gases will go up and reach stratosphere. The chlorine atoms in the gases will act as a catalyst to destroy ozone layer and cause ozone depletion which causes health hazards, global warming, melting of polar ice caps and drought. The refrigerant R22 widely used in the air conditioners is a major Contributor of Chlorofluorocarbons (CFCs) which cause irreparable loss to the ozone layer and has to be replaced.R22 has higher ODP and GWP which is negative point of this refrigerant.R-22 has to replace due to Montreal Protocol and Kyoto protocol there for we have to think about alternative refrigerant and scanning through literature revels that some of the alternative need major change in main component of air conditioner and R-290 could be used as retrofitted refrigerant or some minor change in same system. 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.

Keywords- ODP; GWP; toxicity; flammability; refrigerant

I. INTRODUCTION

The Vapor Compression Refrigeration Cycle is a process that cools an enclosed space to a temperature lower than the surroundings. To accomplish this, heat must be removed from the enclosed space and dissipated into the surroundings. However, heat tends to flow from an area of high temperature to that of a lower temperature.

During the cycle refrigerant circulates continuously through four stages. The first stage is called Evaporation and it is here that the refrigerant cools the enclosed space by absorbing heat. Next, during the Compression stage, the pressure of the refrigerant is increased, which raises the temperature above that of the surroundings. As this hot refrigerant moves through the next stage, Condensation, the natural direction of heat flow allows the release of energy into the surrounding air. Finally, during the Expansion phase, the refrigerant temperature is lowered by what is called the auto refrigeration effect. This cold refrigerant then begins The Evaporation stage again, removing more heat from the enclosed space.

Each of the four stages will now be revisited in detail, explaining the physical changes that occur in the refrigerant and the devices used to accomplish these changes. A visual representation of the cycle is displayed below with the explanation of each stage.

Evaporation

During this stage, the refrigerant travels through a device called an evaporator that has a large surface area and typically consists of a coiled tube surrounded by aluminum fins. The cold fluid is a mixture of liquid and vapour refrigerant as it begins this stage. While flowing through the evaporator, all the liquid evaporates and absorbs heat from the enclosed space. The energy absorbed is used to change the state of the refrigerant from liquid to vapor. This lowers the temperature of the space, along with whatever food or beverages are stored in it. The refrigerant exits this stage as a saturated vapour.

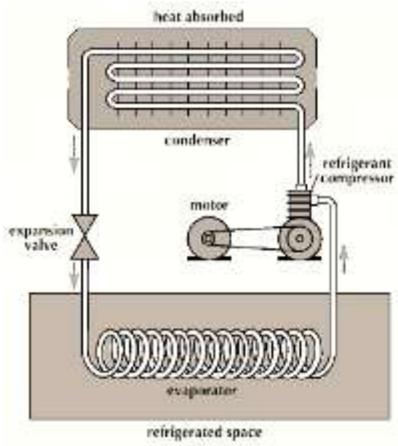

Figure 1 Vapour compression refrigeration cycle compression

The heat that was absorbed in the Evaporation stage must be released into the surroundings, but this will not happen unless the temperature of the refrigerant is higher than the outside air. This is the purpose of the Compression stage. A device, predictably called a compressor, raises the pressure of the refrigerant vapor. Due to basic thermodynamic principles, this causes the temperature of the refrigerant to rise, leaving the stage as a superheated vapor. Energy is needed to power the compressor, which is why electricity is required to operate a refrigerator

Condensation

Now that we have increased the temperature of the refrigerant above that of the surroundings, we can dissipate the heat necessary to continue the process. This is accomplished with a device very similar to the evaporator. It also uses a coiled tube with aluminum fins, but may have different dimensions than the evaporator to accommodate the different state of the refrigerant. As the hot vapor flows through the condenser, the outside air removes energy and the refrigerant becomes a saturated liquid. At this point the slightest drop in pressure will initiate evaporation, which is the basis for the final stage of the process.

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Expansion

To begin a new cycle, all that must happen is a lowering of the refrigeration temperature to below that of the enclosure. This is the key to the entire cycle, because this was the problem that we started with. However, in this situation we can utilize what is called the auto-refrigeration effect. When a saturated liquid experiences a sudden drop in pressure, a small amount of liquid is instantly vaporized and the temperature of the mixture is drastically reduced. This cold liquid-vapor mixture can now begin a new cycle. The pressure drop is accomplished by the simplest, yet most important, part of the system – a simple flow restriction. This part is commonly called a throttle or expansion valve.

II. LITERATURE REVIEW

B. Hadya et al [2]

In this paper, the possibility of using R32 and R290 refrigerants in a vapour compression refrigeration system were studied and compared theoretically with R22.The advantage of R32 is very low flammability with compare to (HCs) R290 but R32 Consumes very high power per TR.

S. Devottaa et al [15]

In this paper some selected fluid is assessed for find out suitable alternative to HCFC-22 for air conditioners.

Thermodynamic analysis has used for find out best alternative.R-134a has highest cop but its capacity is low and that required big compressor which is not good in window air conditioners.

Performance of R-290 is very close to R-22 and compressors need little modification but flammability is negative area and for retrofitting R-407c is best option then other option.

Bukola olalekan bolaji[3]

In this paper experimental works has done and work has been focus on R22, R404A and R507 in a window air-conditioner.

Performance has done on R22 and compared it with performance on R404A and R507.

In retrofitted system low compressor power and energy consumption obtained from R507.Also the highest cop and refrigerating effect obtain from R507.

M. Fatouh et al [12]

In this paper experimental investigation has made for performance assessment of a direct expansion air conditioner working with R407c as an R22 alternative.

The compressor power by 9% and the coefficient of performance by 29.4% for R22 and 23.7% for R407C

S. Devottaa et al [14]

In this paper simulation and experimental both work has done for performance assessment of HC-290 as a drop-in substitute to HCFC-22 in window air conditioner.

In experiment work HC-290 had 6.6% lower cooling capacity for the lower operating conditions and 9.7% lower for the higher operating conditions with respect to HCFC-22.

III. INTRODUTION OF ALTERNATIVE REFRIGERANT

Many researches have taken place to replace the existing traditional refrigerants by refrigerant having similar characteristics with less ozone depletion potential and global warming potential and main focus of this project is to minimize GWP, ODP and power consumption.

R-22

HCFC-22 is one of the important refrigerants used in air-conditioning all over the world. HCFC-22 is controlled substance under the Montreal Protocol. It has to be phased out by 2030 in non-Article 5(2) countries and 2040 in Article 5(2) countries. In Europe, HCFCs have already been phased out in new equipment (below 100 kW capacities) in2002 and the total phase out of HCFCs is scheduled for 2015. In the Western and Northern Europe, HC-290, is being used in small capacity units.

R-290

HC-290 has zero ODP, virtually zero GWP. It is a natural fluid. It has no other effect on climate, although it is considered as volatile organic compound. It is cheap and available in plenty. HC-290 is a pure hydrocarbon compound and it does not give out any toxic decomposing agents on combustion. It is compatible with the materials and lubricants used in refrigeration and air conditioning industry. Due to better miscibility with oil, the oil return to the compressor is not an issue.

R-407C

R-407C has capacity and pressure close to R-22. It is a zeotropic refrigerant with a temperature glide of approximately 6^oC (10^oF) which can lead to greater concerns about maintaining composition control during the distribution, installation, and servicing of this product. Unlike the other two candidates, this refrigerant can be used in either existing systems (requires some changes, e.g. oil) or in new systems that were originally designed for R-22. The efficiency of these systems is somewhat lower with this refrigerant (~5% or so lower than R-22), especially in stems designed for R-22. This refrigerant has seen considerable use in Europe lately due to the accelerated R-22 phase- out and the lack of time to re-design systems for the higher pressure refrigerant, R-410A.

R-410A

R-410A is a higher capacity and higher pressure refrigerant. Systems that utilize this refrigerant would have smaller compressor displacements. When systems are optimized for this refrigerant, heat exchangers could be reduced in size and still achieve comparable capacity and efficiency as R-22. This refrigerant is currently regarded as the leading long-term refrigerant for residential and small commercial applications in North America and Japan as well as other parts of the world.

R-134a

The three HFC options have very different performance characteristics. R-134a is a lower capacity and lower pressure refrigerant than R-22. It would require greater compressor displacement and larger heat exchangers to match the capacity and efficiency of an R-22 air conditioner. At this point in time, it is only used in larger capacity a/c systems that utilize screw or centrifugal compressors. Manufacturers of smaller high volume a/c systems do not view R-134a favorably due to the added expense of building larger systems to handle the same duty as a comparable R-22 system.

Table 1 Environment data of some refrigerants

Refrigerants	**ODP**	**GWP(100 YEARS)**
R-22	0.034	1700
R-134a	0	1300
R-290	0	~20
R-407C	0	1700
R-410A	0	2000

IV. Experimental setup

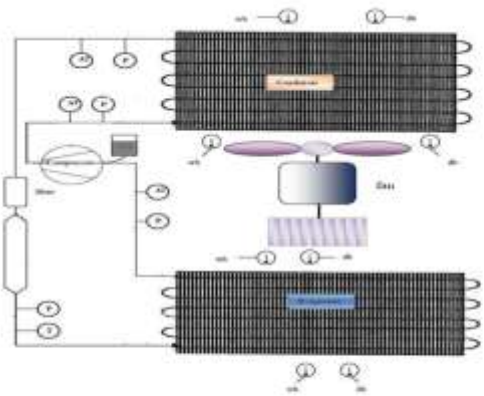

Figure 2 Schematic diagram of the window air conditioner

4.1 Refrigerant Charging

The refrigerant may be charged in a liquid or vapour modes. This is limited by operating factors, such as the amount of refrigerant and time of charging. Charging a refrigeration system, especially the one built-up with capillary tube control, is the most critical task. Amount of refrigerant to be charged is so selected that it maintains desired suction & discharge pressures. It is customary to charge the system with a charging cylinder on volume basis but the short-coming of this method is that since the density of refrigerant varies appreciably with temperature, one can come across erroneous quantity as the charging cylinder does not have different scales for different ambient temperatures. A better alternative method is to charge the refrigerant by weight. Charging without the aid of any equipment requires a high level of skill and human judgment. Sometimes charging is done without the aid of any equipment's; this system uses suction pressure and discharge pressure as indicative of the charge quantity. However, this needs a high level of skill and human judgment. 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.

4.2 TEST PROCEDURE

At the incipience of the test, the system was kept running at least 10 minutes to reach the steady state conditions. This was done by monitoring the temperature and pressure gauge for the circulated refrigerant. After that achievement, the refrigerant side measurements, temperature and pressure, and air side measurements, dry and wet bulb temperature, were recorded. .The tests were usually commenced at highest fan speed

4.3 ANALYSIS OF THE EXPERIMENTAL DATA

The data analysis involved a number of assumptions that are important to be addressed, as described below:

- The mass flow rate of refrigerant is constant at all parts of the experimental test rig.
- The air temperature at the entrance and exit of heat exchangers are constant and homogenous at all tubes in the front and lee sides.

The data reduction procedure includes the refrigerating effect, power consumed by compressor, heat rejected in the condenser, energy efficiency ratio calculated for both R-22 and its alternatives. In addition, (COP) was calculated from the above mentioned parameters.

V. EXPERIMENTAL RESULT AND ANALYSIS

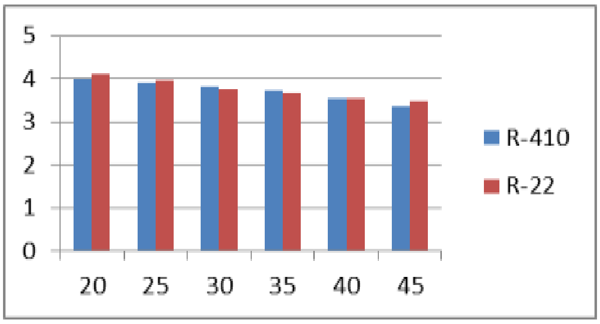

Figure 3 Cop vs. ambient temp

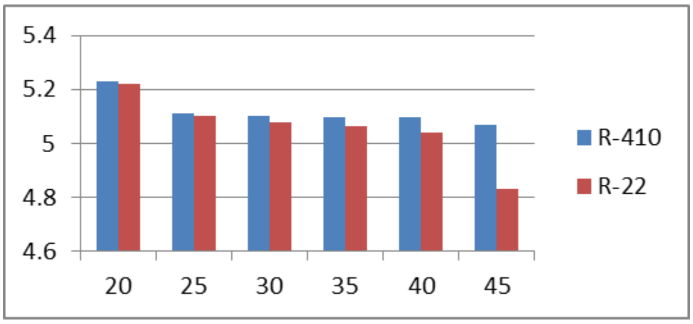

Figure 4 Cooling Capacity (kW) vs.ambient temp

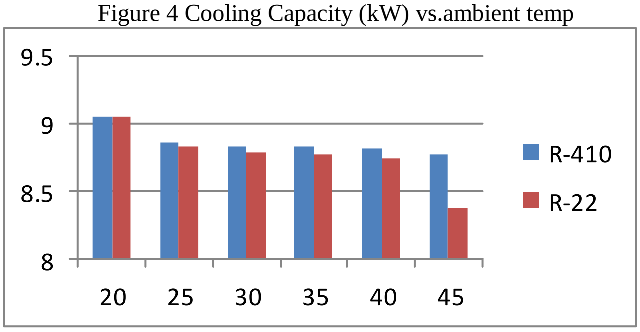

Figure 5 E.E.R VS.AMBIENT TEMP

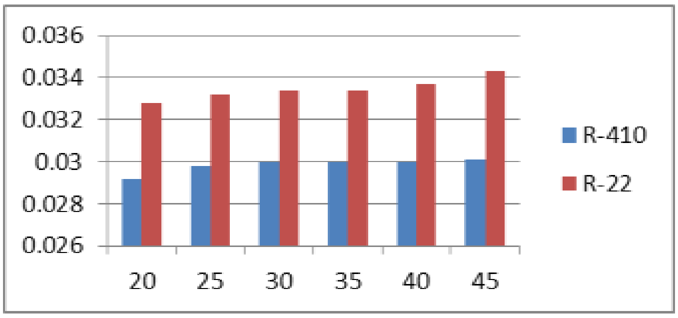

Figure 6 Mass flow rate (Kg/S) vs. ambient temp

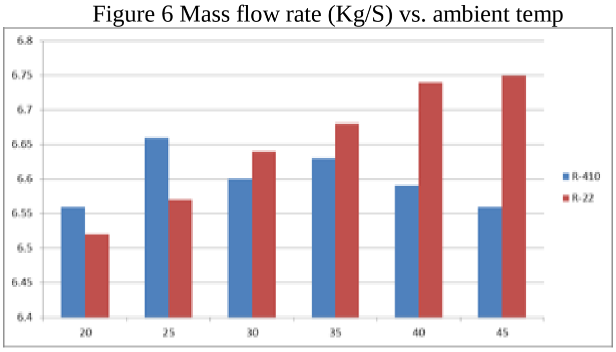

Figure 7 Heat rejected in Condenser (kW) vs. ambient temp

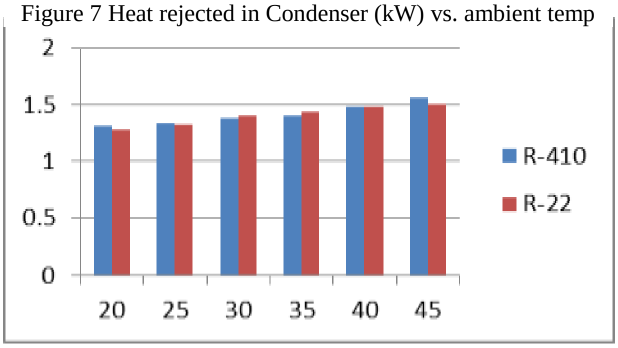

Figure 8 Compressor work (watts) vs. ambient temp

VI. CONCLUSION

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

- The refrigerant capacity and COP reduce and compressor power and pressure ratio increase in case of R410A.
- The performance parameters i.e. refrigeration capacity, COP increases with increase in evaporating temperature in case of R22.
- The compressor power of R410A is higher than R22.
- 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 severe affects our environment. R410A is zero ozone depletion and high volumetric cooling capacity. R410A refrigerant operates at high pressure then R22

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