# Comparison of refrigerant R22 and R407C in Recirculation air conditioning test rig

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***Abstract*—The present work deal with the experimental study to retrofit the refrigerant R407c with the refrigerant R22 in the air conditioning unit at an ambient temperature range between 30-45□C. The main component of the experimental rig includes a window air conditioner with a refrigeration capacity of 2 Ton refrigeration that used refrigerant R22 as a working fluid in the experimental work. The refrigerant R22 is replaced with refrigerant R407C due to similar operation properties for the two refrigerants. The experimental results displayed the refrigeration effect and coefficient of performance COP of the R22 system are high as with those of the R407C system. The falls in the evaporator and condenser for the R407C system is lower than that of the R22 system. The temperature of discharge in the compressor for the system of refrigerant R22 is greater than that of the R407C system. Moreover, condensation temperature along the tube of the condenser is decreased with the increase of the distance for both refrigerants. The refrigerant R407C may be selected as a good alternate for R22 with an agreement difference in the two refrigerants' performance. The system did not require replacement for any part of the AC unit.**

## I. INTRODUCTION

Refrigeration systems play an important role in many fields such as residential cooling, food preservation, transportation, manufacturing processes, and human comfort. Refrigerant R22 has been widely used in air conditioning and refrigeration systems because of its good thermal and chemical properties. However, due to its high global warming potential and ozone depletion effects, it is being phased out under the Montreal Protocol. This has increased the need to find suitable alternative refrigerants for R22.

Many studies have investigated alternative refrigerants such as R407C, R410A, R290, and others in air conditioning systems. Research shows that R22 generally provides better cooling performance and higher coefficient of performance (COP) compared to several alternatives. However, R407C is considered a suitable replacement for retrofitting existing systems, while R410A is more suitable for new system designs. Some hydrocarbon mixtures and refrigerants like R290 also show promising environmental and thermodynamic performance.

Previous studies mainly focused on small-capacity split or window air conditioners under specific operating conditions. The present study experimentally investigates the performance of a 2 TR window air conditioner using R22 and R407C refrigerants under different ambient conditions with a rotary hermetic compressor.

## II. METHDOLOGY

Submit your manuscript electronically for review. The experimental setup was developed to study and compare the performance of two refrigerants under identical operating conditions in a window refrigeration test rig. Before conducting the experiment, all components of the system were inspected carefully to ensure proper operation and to avoid refrigerant leakage. The refrigeration circuit, compressor, condenser, evaporator, expansion device, and measuring instruments were checked and calibrated.


Fig II.2

Initially, the system was charged with refrigerant R22 through the throttling arrangement. After charging, the refrigeration unit was allowed to operate until stable working conditions were achieved. During steady operation, important parameters such as suction pressure, discharge pressure, inlet and outlet temperatures, and cooling characteristics were observed and recorded using the installed measuring devices.

After completing the readings for R22, the refrigerant was completely recovered from the system. The refrigeration setup was then prepared for the next experiment by ensuring that no residual refrigerant remained inside the circuit. Refrigerant R407C was subsequently charged into the same setup under similar operating conditions. The unit was again operated until steady-state conditions were reached, and the same set of readings was collected.

The recorded experimental data for both refrigerants were analyzed and compared to evaluate their operating behavior and performance characteristics. The comparison was carried out on the basis of pressure variation, temperature distribution, refrigeration effect, and overall system efficiency under identical test conditions.

## III. CALCULATIONS

i)Coefficient of performance for R22

$$\text{COP}= \frac{refrigeration\ effect}{comprssor\ work}$$

∴Refrigeration effect

$$\text{RE}= \dot{m}(h_{in} - h_{\text{out}})$$

From psychrometric chart:

$h_{in}$=72 kJ/kg

$h_{\text{out}} = 54$ kJ/kg

$$\text{RE}= 0.499(72 - 54)$$

∴ RE=8.982 kWatts

Now compressor work

$$\text{Compressor work}= \frac{10\ impulses}{time\ for\ 10\ impules} \times_{\text{energy meter coefficient}}$$

$$= \frac{10\ impulses}{11.10\ sec} \times 1.2$$

∴ Compressor work = 3.892 kWatts

Final calculation for COP

$$\text{COP}= \frac{refrigeration\ effect}{comprssor\ work}$$

$$= \frac{8.982}{3.892}$$

∴ COP ≈ 2.076

i)Coefficient of performance for R407c

$$\text{COP}= \frac{refrigeration\ effect}{comprssor\ work}$$

∴Refrigeration effect

$$\text{RE}= \dot{m}(h_{in} - h_{\text{out}})$$

From psychrometric chart:

$h_{in}$=72 kJ/kg

$h_{\text{out}} = 45$kJ/kg

$$\text{RE}= 0.499(72 - 45)$$

∴ RE=13.43 kWatts

Now compressor work

$$\text{Compressor work}= \frac{10\ impulses}{time\ for\ 10\ impules} \times_{\text{energy meter coefficient}}$$

$$= \frac{10\ impulses}{15.20\ sec} \times 1.2$$

∴ Compressor work = 2.84 kWatts

Final calculation for COP

$$\text{COP}= \frac{refrigeration\ effect}{comprssor\ work}$$

$$= \frac{13.473}{2.84}$$

∴ COP ≈ 4.74

## IV. UNITS

Units and Measurement System (SI Units)

$\dot{Q}$: Heat transfer $\dot{m}$: Mass flow rate — kg·s$^{-1}$

$T$: Temperature — K (or °C)

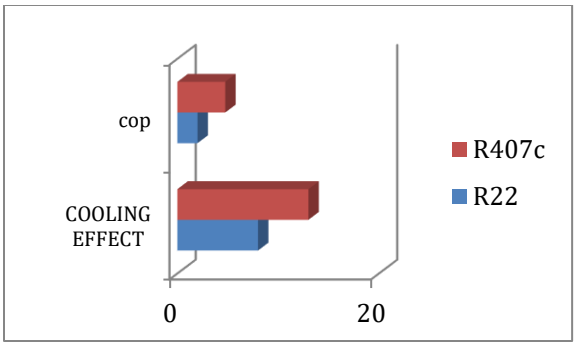
H: Specific heat capacity — $J \cdot kg^{-1} \cdot K^{-1}$ $h$: Heat transfer coefficient — $W \cdot m^{-2} \cdot K^{-1}$
$A$: Surface area — **$m^2$**
$V$: Velocity — **$m \cdot s^{-1}$**
$\rho$: Density — **$kg \cdot m^{-3}$**

Thermophysical Properties
$k$: Thermal conductivity — $W \cdot m^{-1} \cdot K^{-1}$
$\mu$: Dynamic viscosity — $kg \cdot m^{-1} \cdot s^{-1}$
$D$: Characteristic diameter — m
$S_p$: Tube pitch — m

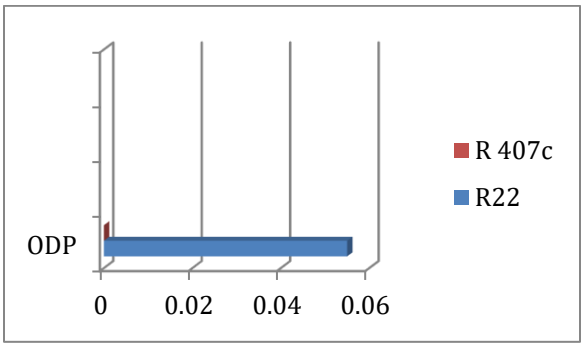
Dimensionless Numbers
$Re$: Reynolds number — Dimensionless
$Pr$: Prandtl number — Dimensionless
$Nu$: Nusselt number — Dimensionless
$\sigma$: Porosity factor — Dimensionless
$COP$: Coefficient of performance Dimensionless
Refrigeration Cycle Parameters
$h_1, h_2, h_3, h_4$: Enthalpy — $J \cdot kg^{-1}$
$\dot{W}$: Compressor work — W
Standard Notes
All quantities are expressed in SI (MKS) units.
Compound units use a center dot (·) (e.g., $W \cdot m^{-2} \cdot K^{-1}$).
Temperature difference may be expressed in K or °C.
No mixing of SI and CGS units is used to maintain dimensional consistency.

## V. RESULT

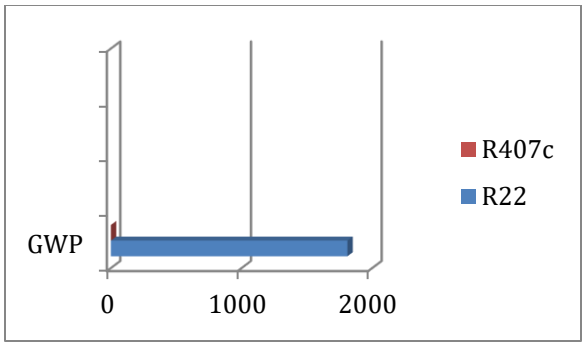
A bar graph is the most suitable method for representing the comparison between R22 and R407C refrigerants. Separate bars can be used to illustrate the COP, ODP, and GWP values of both refrigerants clearly and effectively. The graphical representation helps in understanding the relative performance and environmental impact of the refrigerants at a glance. COP values can be compared to evaluate efficiency, while ODP and GWP graphs highlight environmental considerations. Such comparative graphs are commonly used in research papers because they provide clear visualization and improve data interpretation.




The Coefficient of Performance (COP) is an important parameter used to evaluate the energy efficiency of refrigeration and air-conditioning systems. R22 generally provides a slightly higher COP because of its favorable thermodynamic properties and better heat transfer characteristics. R407C, which is commonly used as a replacement for R22, offers comparable performance but may show a small reduction in efficiency due to temperature glide during phase change. In practical applications, R407C systems can achieve performance close to that of R22 with suitable system modifications. Therefore, R22 is considered marginally more efficient, while R407C remains an acceptable environmentally safer alternative.




Ozone Depletion Potential (ODP) represents the ability of a refrigerant to damage the stratospheric ozone layer. R22 possesses a measurable ODP because it contains chlorine atoms that contribute to ozone depletion. Due to its harmful environmental impact, the use of R22 has been restricted and gradually phased out under international environmental regulations. In contrast, R407C has an ODP value of zero because it does not contain chlorine compounds. This makes R407C a more environmentally acceptable refrigerant for modern refrigeration and air-conditioning systems.




Global Warming Potential (GWP) indicates the contribution of a refrigerant to climate change relative to carbon dioxide. R22 has a high GWP value, which means it contributes significantly to greenhouse gas emissions if released into the atmosphere. R407C also possesses a relatively high GWP, although its value is slightly lower compared to R22. Even though R407C eliminates ozone depletion concerns, its impact on global warming remains an environmental challenge. Consequently, researchers continue to investigate refrigerants with lower GWP values for future sustainable cooling technologies.

## VI. CONCLUSION

The retrofitting process of 2 TR window AC unit using R22 as a refrigerant fluid with its replacement R407C requires the comparison of performance between two refrigernats. The following conclusions from the investigation are illustrated:

1. The refrigerant is charged into the system without making any difference in the system except the compressor oil is changed.
2. The greatest difference in refrigeration effect for R22 and R407C systems is reached to about 5%.
3. The COP of R22 system is greater than those of R407C system with fair difference values, only there is a large difference at ambient temperature 30□C. 4. The R22 system discharge temperature is larger than those for the R407C system.
5. The evaporator and condenser pressure drops for R407C system are lower than those of R22 system. 6. The condensation temperature along the tube of the condenser is decreased as the distance is increased for both refrigerants. The R407C system condensation temperature is greater than that for R22 system at all conditions.
7. The R-407C may be selected as a good alternative to retrofit R-22 due to the R-22 will be phased out.

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