

# International Journal of Innovative Research in Science, Engineering and Technology

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## Replacement of CFCs by Mixture of Butane, Propane and Propylene Refrigerants in Domestic/Commercial Refrigeration Appliances

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**ABSTRACT:** The awareness to protect the environment from the harmful effects of CFCs, which causes depletion of ozone level in the stratosphere region and leads to global warming of the atmosphere, has motivated the refrigeration scientists and engineers to evolve alternate refrigerants to replace the CFCs. This work aims to study the mixture of Butane Propane and Propylene as a possible replacement to CFCs in the domestic and small commercial refrigeration appliances. The various proportions of these refrigerants mixtures have been considered and the thermodynamic properties of these mixtures have been determined over a wide range of temperature and pressure. The calculations have been done considering various parameters and analysis has been carried out for comparing the performance and to evaluate the suitable mixture. Finally the performance evaluation of the mixture has been carried out which concludes that the proposed mixture is potential refrigerant to replace CFCs to protect the environment from harmful effects.

**KEYWORDS:** REFPROP6.01, CFCs, Montreal Protocol.

### I. INTRODUCTION

The purpose of this research was to compare various refrigerants on the basis of their environmental impacts and thermal properties. Refrigerant fluids are a key component for air conditioners and refrigerators, both of which are essential for comfortable living. Since the 19th century there have been many refrigerants developed and used but none of them has as yet become the standard fluid. The objective of this study was to establish an evaluation method that combined the environmental impacts of the most prominent refrigerants and their thermal properties as they apply to the refrigeration process. Initially this work was motivated by the 1987 Montreal Protocol 3, an International agreement by most nations to stop or reduce the manufacture of chloro fluoro carbons (CFCs) and other ozone-depleting substances. This international treat required to stop using the widely used refrigerant, "Freon®", that up to that time was considered as a "miracle compound". Since then, there have been many studies and much discussion about alternative refrigerants. However, as of now there is no single alternative refrigerant for air conditioners.

### II. METHODOLOGY OF REFRIGERANT PERFORMANCE

#### 2.1. The Use of Hydrocarbon Mixtures as Refrigerants in Domestic Refrigerator:-

The study has been carried out for evaluating the performance parameters of a domestic refrigerator using Butane, Propane and Propylene in various proportions as possible alternative replacing the traditional R-12 refrigerant. The proposed alternative refrigerants have the advantage of being locally available, cheap and of an environmentally friendly nature.

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### 2.2. Mixture of Refrigerants Butane (R600) Propane (R290) & R1270 (Propylene):-

R600 isn't really a good option for refrigeration because it doesn't boil low enough. R600 is used in domestic fridges quite a lot. To make a valuable contribution to the protection of environment, high quality, low moisture content R290 refrigerant grade propane can provide us with a cost efficient solution that perfectly suits requirements. High quality, low moisture content R1270 refrigerant grade propene can provide us with a cost efficient solution that perfectly suits requirements.

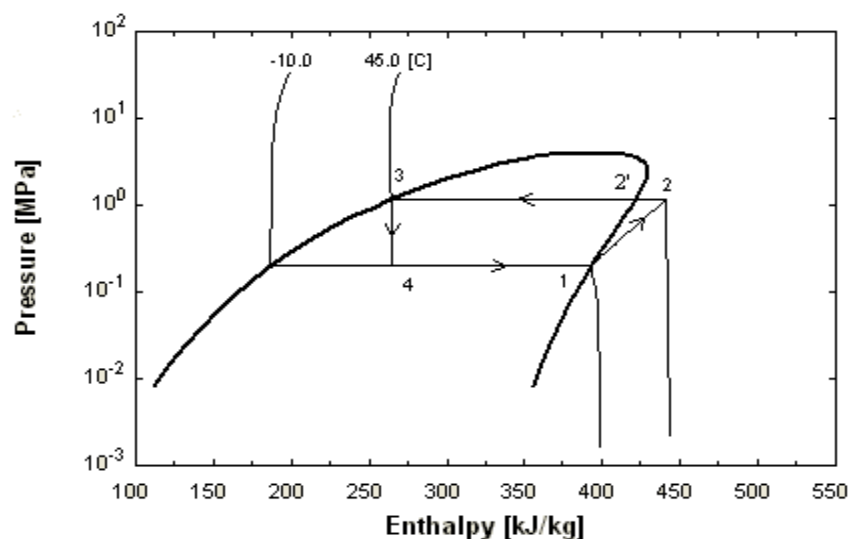
- 2.2.1 Zero ozone depletion potential
- 2.2.2 Very low global warming potential.
- 2.2.3 Excellent thermodynamic properties leading to high energy efficiency
- 2.2.4 Good compatibility with system components
- 2.2.5 Low charges allowing smaller heat exchangers and piping dimensions

### III. THE WORK CARRIED OUT

The present work has been carried out focusing the mixture of Butane Propane and Propylene. First of all refrigerant properties of the Following refrigerants have been found using Refprop 6.01 software. The properties which have been found for the refrigerants R-290, R-600 & R-1270 are as under:-

- All the properties like Temperature, Pressure, Volume, Density, Enthalpy, Entropy, Internal Energy, Specific heat at constant pressure, Specific heat at constant volume, Viscosity, Surface tension, Compressibility and Thermal Conductivity both for the liquid and vapour have been determined.
- The refrigerants mixture of R-290 / R-600 / R-1270 in various proportions has been considered.
- The properties of the various refrigerants and blends are found for the Temperature  $-10^{\circ}\text{C}$  (Evaporating Temperature) and  $50^{\circ}\text{C}$  (Condensing Temperature) Other Various Parameters are also calculated for R-290, R-600, and R-1270. The mixtures of various refrigerants in proper proportions have been made and tabulated and calculation for various parameters like refrigerating effects, compressor work done, COP, mass flow rate and power have been done.
- The pressure enthalpy diagram from PH-1 TO PH-66 has been plotted for the mixture of refrigerants.

### IV. MATHEMATICAL CALCULATION FOR IDEAL CONDITION



$$\begin{aligned} \text{Refrigeration Effect} &= h_1 - h_4 \\ \text{Compressor Work done} &= h_2 - h_1 \end{aligned}$$

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$$\begin{aligned} \text{Coefficient of Performance} &= \text{Refrigerating Effect} / \text{Compressor Work Done} \\ &= h_1 - h_4 / h_2 - h_1 \end{aligned}$$

$h_1$  and  $h_4$  are taken from the P-H curve or from the properties of the refrigerants.

$$h_2 = h_2' + C_p (T_2 - T_2') \dots\dots\dots \text{Eq (1)}$$

$$S_1 = S_2 = S_2' + C_p \ln (T_2 / T_2') \dots\dots\dots \text{Eq (2)}$$

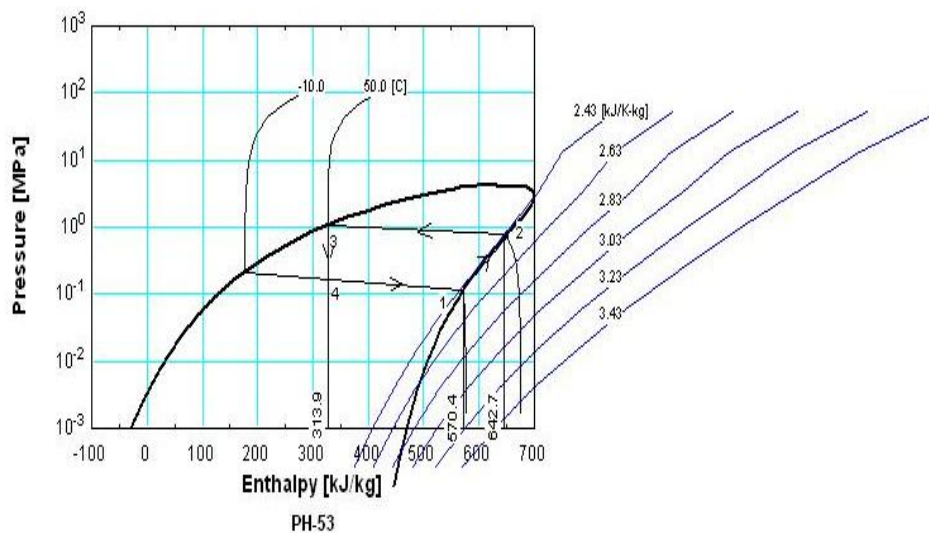
The value of  $S_1$ ,  $S_2'$ ,  $C_p$  and  $T_2'$  are taken from the P-H curve or from the properties of the refrigerants. Then  $T_2$  is calculated from the Eq (2) and put the value of  $T_2$  in Eq (1) and then calculate the value of  $h_2$ .

$$\text{Mass flow Rate} = 3.5 T / \text{Refrigerating Effect.}$$

$$\text{Power (P)} = \text{Mass Flow Rate} \times \text{Compressor Work Done}$$

Where:

- Refrigerating Effect in KJ/Kg
- Compressor Work Done in KJ/Kg
- Mass Flow Rate in Kg/S
- Power in KW.
- T is Ton of Refrigeration
- 1 T = 3.5 KJ / S



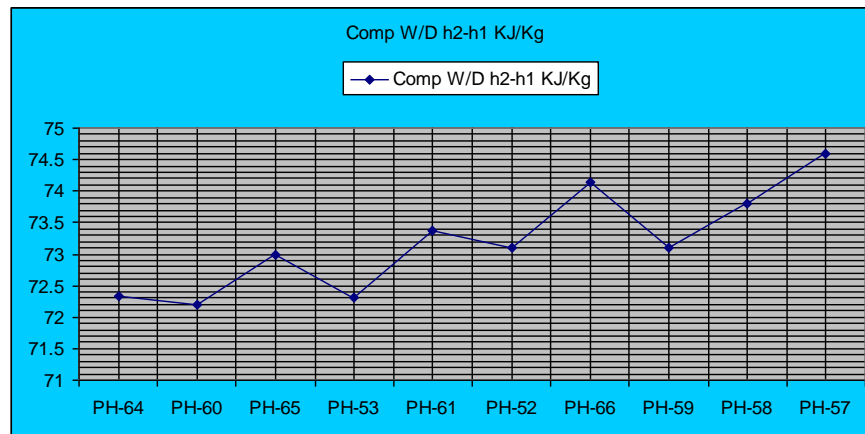
Graph-1

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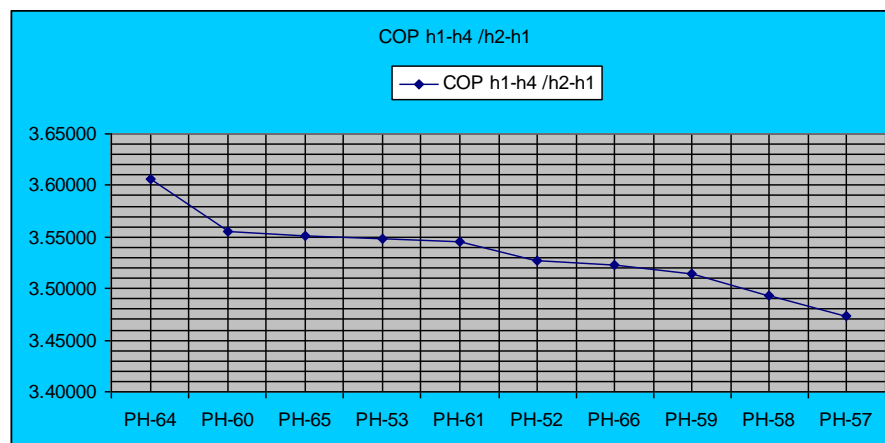
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Graph-2(Compressor Work done and Refrigerants Mixtures)



Graph-3(Cop and Refrigerants Mixtures)

## V. RESULT ANALYSIS

The P-H Curves have been as shown in graph1&2 plotted. The best first ten combinations for the mixture used in PH-64,PH-60,PH-65,PH-53,PH-61,PH-52,PH-66,PH-59,PH-58, PH-57etc.As for the PH-64 refrigerants combination mixture the highest COP is obtained having butane 90% ,propane 10% and propylene0%. The other combinations have also been considered:-

- PH-60 refrigerants combinations butane 70% ,propane 0%,Propylene30%.
- PH-65 refrigerants combinations butane 90% ,propane 0%,Propylene10%.
- PH-53 refrigerants combinations butane60% ,propane 30%,Propylene10%.
- PH-61 refrigerants combinations butane 80% ,propane 20%,propylene0%.
- PH-52 refrigerants combinations butane 60% ,propane 40%,propylene0%.
- PH-66 refrigerants combinations butane 100% ,propane 0%,propylene0%.
- PH-59 refrigerants combinations butane 70% ,propane 10%,Propylene20%.
- PH-58 refrigerants combinations butane 70% ,propane 20%,Propylene10%.
- PH-57 refrigerants combinations butane 70% ,propane 30%,Propylene0%.

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The PH-64 (butane 90% ,propane 10% and propylene0%) refrigerants combinations mixture gives the highest COP but the study was to consider a mixture of three refrigerants which can suitably replace the zoetrope containing two refrigerants (butane and propane).

Therefore PH-53 containing refrigerants (butane60%, propane30%, Propylene10%) give the best results which are as under:-

COP 3.54772, work done 72.3 kJ/kg, refrigerating effect256.5 kJ/kg and its performance is very near to zoetrope's containing refrigerants like (PH-64, PH-60, PH-65).

## VI. CONCLUSION

The main concentration of this study was to consider the environmental friendly combination of the refrigerants mixture. It is found that the Hydrocarbons are mainly environmental friendly. Therefore the alternate substitute the mixture of Butane Propane and Propylene which can be used for the domestic and small commercial refrigeration appliances without the hazard of the global environment and lives.

## VII. FUTURE SCOPE

The mixture of R-600, R290 and R-1270 appears to be a promising alternative refrigerant to CFC for domestic and small capacity commercial refrigeration appliances. The future scope could be to consider:-

1. Evaluation of combinations for further study.
2. Superheating and sub cooling of refrigerants mixtures.
3. The changes which may requires in the VCR system.
4. Detail comparative economical aspects of using this mixture.
5. Change in physical and environmental properties.
6. To justify refrigerants mixtures as proper alternate substitute in domestic appliances.

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