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# PERSPECTIVE OF ENVIRONMENTAL FRIENDLY REFRIGERANT PROPANE (R290)

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**ABSTRACT**

*A refrigerant is a substance used in a heat cycle usually for enhancing efficiency. Traditionally, CFCs and HCFCs were used as refrigerants, but they are being phased out because of their ozone depletion effects. Propane is natural refrigerant having high potential to succeed in the field of refrigeration and air conditioning. This study discusses the different properties of propane, like thermo physical property, environmental characteristics and safety consideration due to its flammability, as refrigerant in commercial application. R290 is having zero ozone depletion potential (ODP) and low Global Warming Potential (GWP) and good thermodynamic properties leading to high energy efficiency.*

***Keywords:Alternative refrigerants, HC290, Refrigeration***

## I. INTRODUCTION

### 1.1 Environment and pollution

One of the greatest problems that the world is facing today is that of environmental pollution, increasing with every passing year and causing irreparable damage to the earth. Pollution is the unwanted introduction of various contaminants into the natural environment that causes adverse change. Developmental activities such as construction, transportation and manufacturing not only deplete the natural resources but also produce large amount of wastes that leads to pollution of air, water, soil, and oceans; global warming and acid rains.

### 1.2 Effects of air pollution on human life

Due to air pollution there is formation of the acid rain in the air damages aquatic life in lakes and streams. Rays from ozone layer with excessive ultraviolet radiation coming from the sun may cause skin cancer. Rays from ozone in the lower atmosphere may destroy lung tissues of the animals and it weakens the lungs to function well. It causes irritation of eyes, nose, mouth, throat, neuron behavioural disorders and premature death also.

### 1.3 Greenhouse gases

Carbon dioxide ($CO_2$) is the primary greenhouse gas emitted through human activities. Carbon dioxide is naturally present in the Atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, Plants and animals). Human activities are altering the carbon cycle—both by adding more $CO_2$ to the atmosphere and by influencing the ability of natural sinks, like forests. While $CO_2$ emissions come from a variety of natural sources, human related emissions are responsible for the increase that

has occurred in the atmosphere since the industrial revolution. The main human activity that emits $CO_2$ is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land use changes also emit $CO_2$.

### 1.4 Global Warming

After the industrial revolution, through fossil fuel combustion, changing agricultural practices and deforestation, the natural composition of gases in the atmosphere is getting affected the climate and environment began to alter significantly. Over the last 100 years it was found out that the earth is getting warmer and warmer, unlike previous 8000 years when temperature have been relatively constant. The key greenhouse gases (GHG) causing global warming is carbon dioxide. CFCs, even though they exist in very small quantities, are significant contributors to global warming. Carbon dioxide, one of the most prevalent greenhouse gases in the atmosphere, has two major anthropogenic (human caused) sources: the combustion of fossil fuels and changes in land use.

### 1.5 Ozone layer depletion

The first global environmental problem identified was the depletion of stratospheric ozone. The ozone layer in upper atmosphere provides a filter for ultraviolet radiation, which can be harmful to health. Researchers found that the ozone layer was thinning, due to emissions of CFC's and HCFC's refrigerants into the atmosphere. The ozone depletion potential (ODP) of a refrigerant represents its relative ability to destroy stratospheric ozone. For the determination of ODP value of other chemicals or refrigerants, reference point usually adopted is ODP = 1 for the CFC R11. The problem of ozone depletion is being overcome by the phasing out of CFC and HCFC refrigerants containing chlorine. Increased penetration of solar UV-B radiation is likely to have profound impact on human health with potential risks of eye diseases, skin cancer and infectious diseases. UV radiation is known to damage the cornea and lens of the eye.

### 1.6 Climate change

The Earth's climate depends on the functioning of a natural "greenhouse effect." This effect is the result of heat-trapping gases (also known as greenhouse gases) like water vapor, carbon dioxide, ozone, methane, and nitrous oxide, which absorb heat radiated from the Earth's surface and lower atmosphere and then radiate much of the energy back toward the surface. Without this natural greenhouse effect, the average surface temperature of the Earth would be about 60°F colder. However, human activities have been releasing additional heat-trapping gases, intensifying the natural greenhouse effect, there by changing the Earth's climate. Climate is influenced by a variety of factors, both human-induced and natural. The increase in the carbon dioxide concentration has been the principal factor causing warming over the past 50 years. Its concentration has been building up in the Earth's atmosphere since the beginning of the industrial era in the mid-1700s, primarily due to the burning of fossil fuels (coal, oil, and natural gas) and the clearing of forests. Human activities have also increased the emissions of other greenhouse gases, such as methane, nitrous oxide, and halocarbons.

## II. OZONE LAYER DEPLETION AND GLOBAL WARMING

Halogenated hydrocarbons have been extensively used as refrigerants. The refrigerants that contain chlorine one of the atoms in their compounds cause ozone depletion and greenhouse effect. Chlorofluorocarbons or CFCs have a major effect on the ozone layer. Halogenated hydrocarbons are extensively used as refrigerants and contain chlorine atoms, which are responsible for the depletion of the ozone layer in the stratosphere of the earth. When halogenated hydrocarbons containing chlorine are released into the atmosphere, they slowly move into the upper layers of the earth's atmosphere where the cloud of ozone is located. Here the chlorine atoms from the halogenated carbons get liberated and they react with ozone converting it into oxygen. Ozone has the capacity to block sun's ultraviolet radiations, but oxygen cannot block them. Here are some of the halogenated hydrocarbon refrigerants that cause ozone layer depletion and greenhouse:

### 2.1 Chlorofluorocarbons (CFCs):

The halogenated carbons that contain at least one atom of chlorine in their compound are called chlorofluorocarbons. The larger the number of chlorine atoms in the CFCs the more their tendency to destroy the ozone layer. The refrigerant R-11 that contains three atoms of chlorine has maximum tendency to deplete the ozone layer. Some of the other dangerous CFCs are R-12, R-113, and R-114. CFCs are considered to be the most dangerous to the ozone layer and greatest cause of the global warming. Their life in atmosphere can be even more than a hundred years. As per the Montreal Protocol signed in 1987, all the CFCs are supposed to be out of production by January 1996 in developed countries and by2000 in the developing countries.

### 2.2 Hydro chlorofluorocarbons (HCFCs):

These are the halogenated hydrocarbons from which not all the atoms of hydrogen are removed. That means they contain at least one atom of hydrogen. The HCFCs used as the refrigerants usually contain lesser numbers of the chlorine atoms and have less overall life in the atmosphere. This makes them less dangerous to the depletion of the ozone layer and the cause of the global warming or greenhouse effect. The HCFC refrigerant most widely used is R-22, which has Relative Ozone Destruction Efficiency of 0.05.Since they have less detrimental effects, HCFCs are being used as the transitional refrigerants till the new alternative refrigerants for various applications are found. Eventually, all the HCFCs have also to be phased out by the year 2030.

## III. EFFORT PUT AT ORIENTATION LEVEL TO CONTROL GLOBAL WARMING AND OZONE LAYER DEPLETION

### 3.1 Montreal protocol

In 1981, in response to the growing scientific consensus that CFCs and halons would deplete the ozone layer, the United Nations Environment Programme (UNEP) began negotiations to develop multilateral protection of the ozone layer. These negotiations resulted in the Vienna Convention for the protection of ozone layer, adapted in March 1985. The convention provided a framework for international co-operation in research, environmental monitoring and information exchange. In September 1987, 24 nations, among which the United States, Japan, the Soviet Union, certain country members of the European Community, the developing countries Egypt,

Ghana, Kenya, Mexico, Panama, Senegal, Togo and Venezuela, as well as the European Community, signed the Montreal Protocol on substances that deplete the ozone layer.

### 3.2 Kyoto Protocol

The agreement was negotiated in Japan's ancient capital of Kyoto in 1997. 141 nations all over the world have signed the treaty and supported it. It targets carbon dioxide and five other gases that can trap heat in the atmosphere and are believed to be behind rising global temperatures. It legally bound industrialized nations to reduce worldwide emissions of greenhouse gases.

## IV. ENVIRONMENTALLY FRIENDLY REFRIGERANTS

Presently, HCFC22 is widely used and well performing refrigerant but is to be phased out urgently in coming years because of the environmental damage it has caused. Based on scientific findings, regulatory requirements and market pressure, the governing selection criteria for the new alternative refrigerants are changing. New long term alternative should have not only zero ODP but it should low GWP value – initially 150 or less with old requirements of suitability, safety, and material compatibility. At the same time it should have short (but not too short) atmospheric life. Most important, new alternative must offer high efficiency to reduce indirect contribution to the greenhouse effect. Although, chlorine free HFC refrigerants like R134a, R404A, R507A, R407C and R410A have been tried as a replacement to HCFC22, are also to be phased out because of their considerable global warming potential. There is need to identify a refrigerant which will significantly reduce, direct emissions caused by refrigerant loss and indirect emissions through highly efficient plants.Thus, the dominant requirements for alternative refrigerant are that they should be efficient in operation and that they should have low GWPs and zero ODP. The number of substances satisfying these requirements and can be used as refrigerant are relatively limited. It is very unlikely that any new single component refrigerant will be discovered, exhibiting similar thermal performance to R22.Under these circumstances, refrigeration and air conditioning industry is going back to natural refrigerants.

## V. NATURAL REFRIGERANT

Natural refrigerants include a range of organic and inorganic compounds suitable for use in a variety of refrigeration and air conditioning system applications and presenting a variety of issues and challenges. Thus the successful application of these refrigerants will vary depending on the compound. These materials include ammonia, carbon dioxide, natural hydrocarbons, water and air." The advantages of natural refrigerants have led to a significant increase in their use in recent years in applications traditionally served by fluorocarbons. For ammonia and hydrocarbons, a major goal of current development is to decrease the refrigerant charge in refrigerating systems in order to address safety concerns. Through careful design, it is often possible to reduce the required quantity of refrigerants in systems by the application of design techniques.

### 5.1 Propane

Propane (R290) is an eco-friendly refrigerant which has very low Global Warming Potential and zero Ozone Depletion Potential. It is a Hydrocarbon refrigerant. Propane has excellent thermal performance, low price, and

R290 can be compatibilities with general machinery lubricants and structural material, ODP = 0, GWP is small, does not require synthesis, not to change the content of the nature of the hydrocarbon, has no direct impact on the greenhouse effect. R290 is a non-ozone depleting refrigerant and GWP value is 20, which is very low as compared to GWP of R134a. R290 is classified as A3 as per ASHRE34-2010. However lower flammability limit (LFL) for R290 is 0.038 kg/m$^3$ by mass. To avoid risk due to flammability, charge in the system should be well below the LFL. It is observed that R290 is good replacement for other refrigerant due to its good compatibility and performance. Propane greater cooling capacity as compared to other refrigerant

**5.1.1 Thermo Physical Properties**

Molecular weight of weight of R290 is less as compared to other refrigerant. R290 has the slightly highest critical temperature; the highest is the latent heat of vaporization that normally means higher efficiency. Lower saturation pressure allows ease in manufacturing of refrigeration system.

**Table 1. Thermophysical Properties**

| **Refrigerant** | Molecular Weight | Normal B.P. $^0$C | Critical Temp. Tc$^0$C | Critical Press MPa. | Latent heat of Evap. kJ/kg |
|---|---|---|---|---|---|
| **R290** | 44.10 | ~42.2 | 96.7 | 4.25 | 425.4 |

**5.1.2 Environmental characteristics**

Atmospheric life of R-290 is very less as compared to other which means it will sustain in environment for very less time and hence it is environment friendly. HC-290 is a non-ozone depleting refrigerant whereas most of the refrigerant is a non-zero ODP refrigerant. GWP value of HC-290 is 20, which is very low compared to other.

**Table 2. Environmental characteristics**

| **Refrigerant** | Atm. life (Years) | ODP(R11=1) | $GWP_{100yr(CO2=1)}$ |
|---|---|---|---|
| **R290** | 0.041 | 0.000 | 20 |

**5.1.3 Safety characteristics**

For the development of HC-290, flammability and toxicity are very important parameters due which it was neglected alternative for so many years. R290 is classified under A3 safety class as per ASHRE34-2010 due to this it has been avoided. But it has good thermo physical properties which is similar to R22, hence can be effectively used with taking proper care of leakage factor during operation. The European standard EN378 gives the safety requirements for the use of flammable refrigerants in various applications. Toxicity safe index for HCFC22 and R290 are similar.

**Table 3. Safety characteristics**

| **Refrigerant** | LFL by mass kg/m3 | LFL by volume % | Burning velocity cm/s | Combustion heat MJ/kg | Toxicity ppm. | Safety class |
|---|---|---|---|---|---|---|
| **R290** | 0.075 | 2.1 | 46 | 50.3 | 1000 | A3 |

When considering a mixture of a flammable fluid and air, burning or explosion can occur upon contact with a source of ignition in the case that the mixture concentration is between the lower explosive limit (LEL) and the upper explosive limit (UEL) and Stored in a cool, ventilated coffers away from fire and the heat source.

Propane sensors have been installed nearby the compressor and inside electrical panels. These sensors detect from 0 - 20% of the LEL and different safety levels have been considered depending on the concentration measured by the sensors.

## VI. CONCLUSION

From the above study since, the ODP value of propane is zero and GWP value is very low. it can be concluded that it does not affect the environment in term of global warming and green house effect which are major drawbacks of present refrigerant. Moreover it is naturally occurring refrigerant and its physical and chemical properties allow it to be effective alternative for existing environmental harmful refrigerant.

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