The Study of Global Warming Potential and Ozone Depletion Potential of Different Refrigerants in VCRS

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UNDERTAKING

I declare that the work presented in the Major Project entitled "***The Study of Global Warming Potential and Ozone Depletion Potential of Different Refrigerants in VCRS***", submitted to the Department of Mechanical Engineering, School of Engineering & Technology, Adamas University, Kolkata is my original work. I have not plagiarized or submitted the same work for the award of any other degree. In case this undertaking is found incorrect, I accept that my degree may be unconditionally withdrawn.

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CERTIFICATE

Certified that the work contained in the Major Project entitled "**The Study of Global Warming Potential and Ozone Depletion Potential of Different Refrigerants in VCRS**", by Koushik Kumar Das, Saptarshi Mondal, Biswajit Maji has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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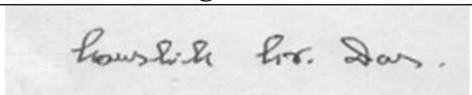
Koushik Kumar Das	
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ABSTRACT

Vapor-compression refrigeration or vapor-compression refrigeration system (VCRS), in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings and automobiles. It is also used in domestic and commercial refrigerators, large-scale warehouses for chilled or frozen storage of foods and meats, refrigerated trucks and railroad cars, and a host of other commercial and industrial services.

It can be shown that the GWP & ODP values of the blend mixture (R-22 + R-600a) will be lesser than of the commercial refrigerants, which are been used in the commercial refrigeration system.

Keywords: VCRS, GWP, ODP.

Contents

Chapter 1

Introduction

1.1 Motivation

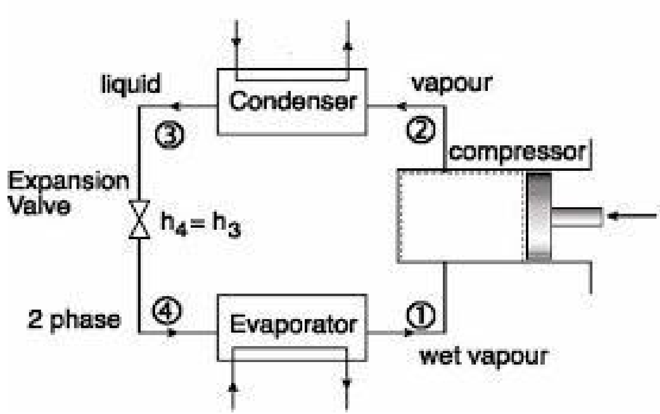
Chlorofluorocarbons (CFCs) have been used extensively in last five or six decades as refrigerants in the vapor compression cycle. In recent years it has been found that CFCs are most destructive to the environment.

The impact of refrigeration systems and air conditioning on stratospheric ozone are mainly related to the emissions of refrigerants that deplete the ozone.

The contribution of these systems in terms of global warming has its origins in the emissions of refrigerants.

1.2 VCRS

Vapor-compression uses a circulating liquid or gaseous state of refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. All such systems have four components: a compressor, a condenser, a thermal expansion valve (also called a throttle valve or metering device), and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air (whichever may be the case).



The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapor refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser.

To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor. Over time, the evaporator may collect ice or water from ambient humidity. The ice is melted through defrosting. The water from the melted ice or the evaporator then drips into a drip pan, and the water are carried away by gravity or by a pump.

Advantages of VCRS

1. Very mature technology.
2. Relatively inexpensive.

3. Can be driven directly using mechanical energy (water, car or truck motor) or with electrical energy.
4. Efficient up to 60% of Carnot's theoretical limit (as evaluated in ASHRAE testing conditions: evaporation temperature of −23.3 °C, condensing temperature of 54.4 °C, and ambient temperature of 32 °C based on some of the best commercially available compressors, as produced by manufacturers Danfoss, Matsushita, Copeland, Embraco, Bristol, and Tecumseh. However, many refrigeration systems use compressors that have lower efficiencies of between 40–55%, since the 60% efficient ones cost almost twice as much as the lower efficiency ones.

1.3 Refrigerant

A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. In most cycles it undergoes phase transitions from a liquid to a gas and back again. Many working fluids have been used for such purposes. Fluorocarbons, especially chlorofluorocarbons, became commonplace in the 20th century, but they are being phased out because of their ozone depletion effects. Other common refrigerants used in various applications are ammonia, sulfur dioxide, and non-halogenated hydrocarbons such as propane.

- **Types of Refrigerant Blend:**

A refrigerant blend or mixture of refrigerants is made up of two or more single component refrigerants. These blends can be of two types:

- **Azeotropic Blend:**

These blends behave like a single component refrigerant, in that they boil and condense at a constant temperature at a given pressure. In the ASHRAE refrigerant designation, these blends are assigned numbers (or ASHRAE codes) in the 500 series, e.g. R-509A.

- **Zeotropic blends:**

These blends boil and condense through a range of temperatures at a given pressure. This range of temperatures is called the ‘temperature glide’.Zeotropic blends are assigned ASHRAE codes in the 400 series, e.g. R-401A, R-406A, etc.

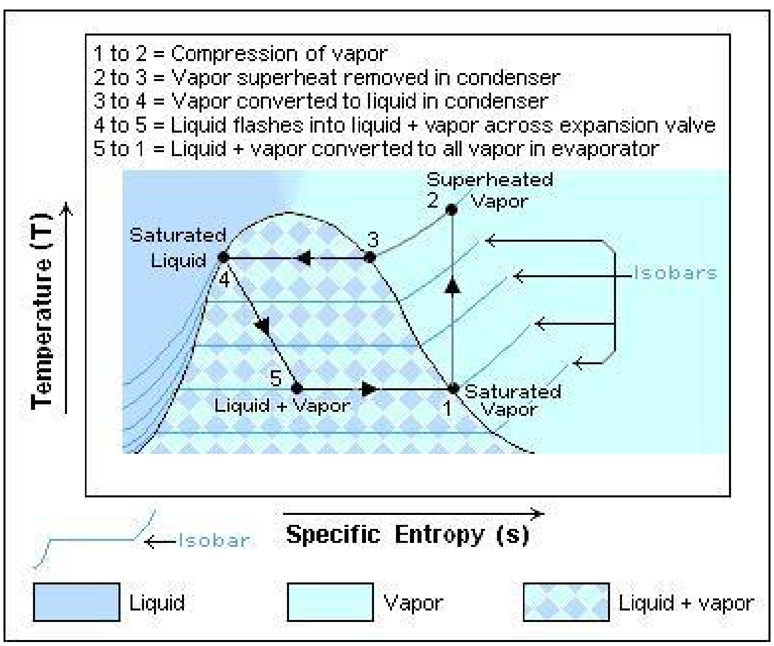
- **Drawbacks of Refrigerant:**

The inert nature of many halo-alkanes, chlorofluorocarbons (CFC) and hydro-chlorofluorocarbons (HCFC), particularly CFC-11 and CFC-12, made them preferred choices among refrigerants for many years because of their non-flammability and non-toxicity. However, their stability in the atmosphere and their corresponding global warming potential and ozone depletion potential raised concerns about their usage.

1.4 Thermodynamic analysis of VCRS

Literally, VCRS governs by Clausius Statement, which state that, it is impossible to develop a device which works on a cycle and produce no other effect other than heat transfer from a cold body to a hot body.

The thermodynamics of the vapor compression cycle can be analyzed on a temperature versus entropy diagram as depicted in figure. At point 1 in the diagram, the circulating refrigerant enters the compressor as a saturated vapor. From point 1 to point 2, the vapor is isentropically compressed (compressed at constant entropy) and exits the compressor as a superheated vapor. Superheat is the amount of heat added above the boiling point.



From point 2 to point 3, the vapor travels through part of the condenser which removes the superheat by cooling the vapor. Between point 3 and point 4, the vapor travels through the remainder of the condenser and is condensed into a saturated liquid. The condensation process occurs at essentially constant pressure.

Between points 4 and 5, the saturated liquid refrigerant passes through the expansion valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes). The adiabatic flash evaporation process is isenthalpic (occurs at constant enthalpy).

Between points 5 and 1, the cold and partially vaporized refrigerant travels through the coil or tubes in the evaporator where it is totally vaporized by the warm air (from the space being refrigerated) that a fan circulates across the coil or tubes in the evaporator. The evaporator operates at essentially constant pressure and boils off all available liquid there after adding 4–8 kelvins of superheat to the refrigerant in order to make sure the liquid has evaporated completely. This is a safeguard for the compressor, as it cannot pump liquid. The resulting refrigerant vapor returns to the compressor inlet at point 1 to complete the thermodynamic cycle.

1.5 Global Warming Potential

It is a measure of how much heat a greenhouse gas (CO_2, N_2O, Freon etc.) traps in the atmosphere up to a specific time horizon relative to CO_2. GWP is 1 for CO2. For other gases it depends on the gas and the time frame. Some gases, like methane, have large GWP, since a ton of methane absorbs much more heat than a ton of CO2. Some gases, again like methane, break down over time, and their heat absorption, or GWP, over the next 20 years is a bigger multiple of CO2 than their heat absorption will be over 100 or 500 years. Values of GWP are estimated and updated for each time frame as methods improve.

The change in net radiation at the tropopause caused by a given change in greenhouse gas concentration or mass is referred to as radiative efficiency. Radiative efficiency has units of W m-2 ppb-1 or W m-2 kg-1; it is calculated using radiative transfer models of the atmosphere and depends upon the strength and spectral position of a compound's absorption bands. The Absolute Global Warming Potential (AGWP) has units of W m-2 ppb-1 year or W m-2 k-1 year.

It can be define as the ratio of radiative forcing capacity (RF) of a substrate to Co2.

Radiative Forcing Capacity:

It is define as, the amount of energy per unit area, per unit time, absorbed by the greenhouse gas.

1.6 Ozone Depletion Potential

ODP of a substance is the relative amount of degradation to the ozone layer it can cause, with CFC-11 or R-11(ODP=1). It is the ratio of global O3 loss due to unit mass emission of a ODS to the refrigerant of CFC-11. Also ODP's are indices that provide a simple way to compare the relative ability of various Ozone Depletion Substances to destroy stratospheric Ozone.

ODP = [Global Ozone loss due to unit mass emission of a ODS / Global Ozone loss due to unit mass emission of CFC-11(ODP=1)]

And these mass emissions depend upon the fractional halogen release factor, the global life-time, the molecular weight of the Ozone Depletion Substances. This quantity can be calculated using computer models, with the accuracy depending on the model's ability to simulate the distribution of the considered halocarbon and the ozone loss associated with it. Because ODPs are defined relative to the ozone loss caused by CFC-11, the ODP values demonstrate less sensitivity to photochemical modeling errors than do absolute ozone loss calculations.

Chapter 2

2.1 Objective

Main objective of the project was to calculate COP of the VCRS system, GWP & ODP of (R-12, R-600a & R-22 mixture) refrigerants. We have found the GWP & ODP values of individual refrigerant from internet, and calculate of these values of the blend of refrigerants.

2.2 Readings

Measured the temperature by using thermo-couple and find out the entropy corresponding to temperature of R-12.

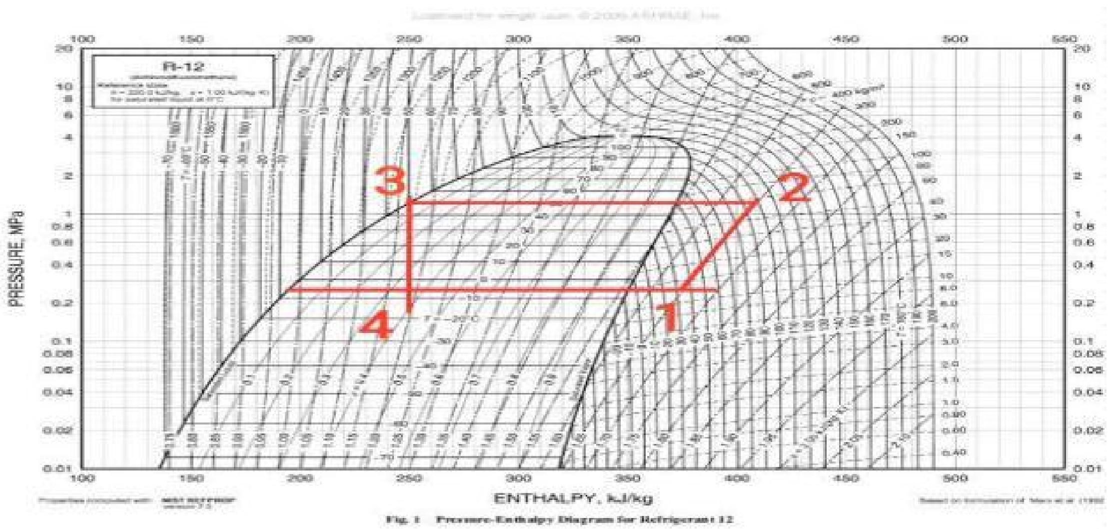
NAME OF REFRIGERANT	COMPRESSOR INLET TEMP. (T1)	COMPRESSOR OUTLET TEMP. (T2)	CONDENSER OUTLET TEMP. (T3)	EVAPORATOR INLET TEMP. (T4)
R-12	**35.2^{0}C**	**96.3^{0}C**	**50.7^{0}C**	**-5.5^{0}C**

SPECIFIC ENTHALPY	h_1	h_2	h_3	h_4
	375 KJ/Kg	**410 KJ/Kg**	**250 KJ/Kg**	**250 KJ/Kg**

Chapter 3

Result & Discussion

3.1 P-H diagram of R-12 refrigerant using experimental readings-



After calculating the COP,

Co-efficient of Performance of VCRS using R-12 refrigerant = 3.57

The usable formula of GWP & ODP-

GWP of Blend	=	Proportion by % mass of component **A** x GWP of **A**	+	Proportion by % mass of component **B** x GWP of **B**
ODP of Blend	=	Proportion by % mass of component **A** x ODP of **A**	+	Proportion by % mass of component **B** x ODP of **B**

3.2 Calculation of the GWP & ODP-

NAME OF REFRIGERANT	R-12	R-22	R-600a	BLEND OF (R-22+R-600a)
GWP	10200	1760	3	(0.4*1760)+(0.6*3) =705.8
ODP	1	0.05	0	(0.4*0.05)+(0.6*0)= 0.02

Chapter 4

Conclusion & Future work

- It can be shown that the GWP & ODP values of the blend mixture will be lesser than of the commercial refrigerants, which are been used in the commercial refrigeration system.
- The blend of refrigerants used as the ratio of 2:3 means, 40% of R-22 and 60% of R-600a refrigerant. The GWP & ODP of R-600a refrigerant is very low comparative to R-22, so that is the reason the quantity of R-600a refrigerant is higher than the R-22 in this blend.
- After testing it we obverse that, in future the volumetric ratio of these two refrigerants in the blend can be varied, to get the optimized value of GWP & ODP.

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