Properties of Various Refrigerants and Alternatives to R22 Refrigerants

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Abstract

This study is concerned with the properties of some common refrigerants and alternatives for R22 refrigerant which would be banned by 2020. Stability of CFC (Chlorofluorocarbons) and HCFC (Hydro-chlorofluorocarbons), their global warming potential and ozone depletion potential make them unsuitable for use. Refrigerants such as R410A, R134a, R407C and R407A are some proposed alternatives for R22 refrigerant. Their properties have been mentioned in this article.

Keywords: Refrigerants, R22 refrigerant, HCFC, CFC.

Introduction

Any substance that is capable of absorbing heat from another substance can be used as a refrigerant [1]. Due to the presence of chlorine in HCFCs and CFC refrigerants ozone layer is depleting. To prevent this, the use of chlorine free refrigerants and replacements for widely used R22 refrigerant which has a high global warming potential and ozone depletion potential is under study. Some alternatives for R22 have been mentioned in this article.

Some Important Terms

- Azeotropes are the mixtures of different refrigerants which do not separate into their components with changes in temperature and pressure [1].
- Ozone Depletion Potential: It is defined as a measure of ozone depletion capability of a refrigerant compare to that of CFC11, which has ODP of 1 [2].
- Global Warming Potential: GWP: Compares the warming effect of a gas compared to that of CO2 by weight whose GWP is standardized to 1 [3].
- Temperature glides: Because the composition of a zeotropealters during a phase changes, there is a slight change in their evaporating and condensing temperature at constant pressure. This phenomenon is known as temperature glide [3].
- Zeotropes are the blends when used in refrigeration cycle, change their volumetric composition and saturation temperatures to varying extents as evaporate or condense at constant pressure [3].

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Halogen Free Refrigerants

Carbon Dioxide

Carbon dioxide is nontoxic, non-flammable but requires a higher operating pressure. Its critical temperature is 45^0C and critical pressure is 73.8 bar.

Since its operating pressure is high, heavy equipment's and tubes of larger thickness have to be used thus adds to the system costs [2].

Ammonia (R717)

Ammonia is still used to greater extent due to its low volumetric displacement, low cost and high efficiency. Presently it is widely used in cold storages and ice manufacturing plants. But ammonia has some drawbacks:

- It is toxic and flammable.
- In presence of moisture, it forms an emulsion with oil that causes operating difficulties.
- It becomes explosive when mixed with air and compressed [1].

Hydrocarbons

Propane (R-290) is a halogen-free substance with no ozone-depletion potential and low GWP and can be a replacement for R22. It is widely available and is a low cost substance.

The operating pressures of a refrigeration system with propane are similar to R-22. But the disadvantage of propane and all hydrocarbons is that they are highly flammable. Safety measures are required which adds to system cost. Special considerations must be taken for excess pressures and electrical connections and ventilation to prevent a flammable gas mixture which restricts its use in market [3].

R22

R22 has been phased out due to its ozone depletion potential. It contains chlorine which has a damaging effect on ozone layer. A complete ban will be imposed on its use by year 2020.

Therefore many alternatives are understudy which can be the replacement for this refrigerant.

Table 1.Properties of R22 [4]

Molar mass	88.468 kg/kmol
Boiling point	-40.81^0C
Critical temperature	96.145^0C
Critical pressure	49.9 bar
ODP	0.05
GP	1810

Alternatives for R22

Following are the alternative of R22 refrigerants used by industries.

R134a

Due to the damaging effect of CFCs and HCFCs refrigerants to ozone layer, the HFC family of refrigerants has been widely used as their replacement.

It is now being used as replacement for R12. It is safe for normal handling as it is nontoxic, non-flammable and non-corrosive. It doesn't have any temperature glide as it is a single component refrigerant.

Due to its properties is has also been proposed for replacement of R22. But its disadvantage lies in its fairly low capacity as compare to R22.

For its use, the heat exchanger's tubing needs to be large to minimize pressure drop and maintain acceptable operating efficiency. The heat transfer coefficient is also lower than R22.

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It is mainly used in automotive air conditioning [3].

Table 2.Properties of R134a [4]

Molar mass	102.03 kg/kmol
Boiling point	-26.074^{0}C
Critical temperature	101.6^{0}C
Critical pressure	40.593 bar
ODP	0
GWP	1300

R407A

R407A is a blend of R32 (20%), R125 (40%) and R134a (40%). It offers a lower global warming potential and zero ODP. It was designed for low and medium temperature refrigeration applications.

Its good capacity and efficiency match for R22 makes it well suit for R22. Discharge temperatures of R407A found to be lower than R22 but system pressures are high [3].

Table 3.Properties of R407A [4]

Boiling point	-38.9^{0}C
Critical temperature	82^{0}C
Critical pressure	45.15 bar
ODP	0
GWP	2107

R407C

R407C is a blend of R32 (23%), R125 (25%), R134a (52%) [4]. It has been proposed as a substitute of R502 and R22. It was designed to have operating characteristics similar to R22. But it has a disadvantage of high temperature glide and efficiency degradation compare to R22. However, in the systems where glide is acceptable R407C can be used as an effective alternative to R22. Its lower efficiency performance as compare to R410A makes it less attractive alternative than R410A [3].

Table 4.Properties of R407C [4]

Molar mass	86.204 kg/kmol
Boiling point	-43.8^{0}C
Critical temperature	86.034^{0}C
Critical pressure	46.298 bar
ODP	0
GWP	1770

R410A

R410A is a blend of R32 (50%) and R125 (50%). It is nonflammable, non-toxic refrigerant with zero ozone depletion potential. It offers higher cooling capacity and negligible temperature glide (0.1%).It is not compatible with mineral oils and requires polyester oils for its use. It is a high pressure refrigerant as compare to R22 so it cannot be retrofitted. Although operating pressures are higher than R22, R410A system run slightly cooler than R22 due to the higher vapor heat capacity of the refrigerant. It also has better low temperature efficiency and low discharge pressures. It also requires smaller tubing therefore reduction inn system cost. Experiments have shown that there can be 2% gain in compressor efficiency with R410A refrigerants. However COP obtained with R410A is lesser as compared to R22 [6].

Table 5.Properties of R410A [4]

Molar mass	72.585 kg/kmol
Boiling point	-51.4^{0}C
Critical temperature	71.358^{0}C
Critical pressure	49.026 bar
ODP	0
GWP	2000

R290

R290 has zero ODP and virtually zero GWP. Although considered as volatile organic compound it has no other harmful effect on environment. It is also compatible with oils and

lubricants used in HVAC industry. But the disadvantage lies in its flammability. It is classified as a highly flammable refrigerant which restricts its use in residential and commercial air conditioning. However significant changes in product design and use of safety measures can avoid the risk of using flammable refrigerants but it will add to the cost of the system. Studies have shown that COP obtained with R290 is more as compare to R22 and power consumption is also less. Discharge pressures were also low as compare to R22 [7].

Table 6.Properties of R290 [4]

Molar mass	44.1 kg/kmol
Boiling point	42.1^0C
Critical temperature	96.7^0C
Critical pressure	42.5 bar
ODP	0
GWP	-20

Conclusion

The Montreal protocol is regarding the phasing out of those substances which cause ozone layer depletion. HCFCs and CFCs refrigerant cause much harm to ozone layer due to presence of chlorine which reacts with ozone and deplete it. R22 is going to be banned by year 2020 in all refrigeration and air conditioning systems. .That's why it has become essential to find some other alternatives which may be HFCs or other halogen free refrigerants. The objective of this article is to know about such alternative refrigerants and some of their properties. R410A is currently being used in many HVAC industries as a replacement for R22. But being a high pressure refrigerant as compare to R22 the air conditioning systems have to be modified.

References

[1] Arora SC, Domkundwar S. A course in Refrigeration and Air Conditioning. *Dhanpat Rai and Co (Pvt) Ltd*, Delhi, 2000.

[2] Arora RC. Refrigeration and Air Conditioning. *PHI Learning Private Limited*, New Delhi, 2010.

[3] Refrigeration for commercial refrigeration applications, Emerson Climate Technologies, 2011. Available from: http://www.emersonclimate.com/White%20Papers/White%20Papers%20Soon%20To%20Be%20Deleted/ECT2005ECT162.pdf.

[4] Venkataiah S, Venkata Rao G. Analysis of Alternative Refrigerants to R22 for Air-Conditioning Applications at Various Evaporating Temperatures. *International Journal of Engineering Research and Applications* 2014; 4(3): 39-46.

[5] Released for R407A/R407F refrigerants. Headline Myriad Pro Bold. Danfoss. September, 2014. Available from: http://files.danfoss.com/technicalinfo/dila/17/ FRCC.EN.139.A2.22.pdf.

[6] Jadhav SS, Mali KV. Evaluation of a Refrigerant R410A as a Substitute for R22 in Window Air-Conditioning. *IOSR Journal of Mechanical and Civil Engineering* 4: 23-32. Available from: http://iosrjournals.org/iosr-jmce/papers/RDME-Volume4/RDME-34.pdf.

[7] Padalkar AS, Devotta S. Natural Refrigerants, Sustainable Ozone and Climate Friendly Alternatives to HCFCs. Deutsche Gesellschaft fur, Technische Zusammen arbeit (GTH) GmbH-German Technical Corporation-Programme Proklima, 2008.