Unit III: Selection of Refrigerant

Choice of Refrigerant: Important refrigerants, secondary refrigerant, anti-freeze solution, selection of refrigerant for required purpose.

Q. What is 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.

Q. How Refrigerant Works

Without refrigerant, there would be no air conditioning, refrigeration or freezing technology. Air conditioners contain refrigerant inside copper coils. As refrigerant absorbs heat from indoor air, it transitions from a low-pressure gas to a high-pressure liquid. Air conditioning components send the refrigerant outside where a fan blows hot air over the coils and exhausts it to the exterior.

The refrigerant then cools down and turns back into a low-pressure gas. Another fan located inside the home blows air over the cool coils to distribute the resulting cold air throughout the building. Then the cycle repeats.

Q. Write down the Types of Refrigerants

The most common refrigerants used for air conditioning over the years include:

- **Chlorofluorocarbons (CFCs)**, including R12. This is known to contribute to the greenhouse gas effect. Production of new stocks ceased in 1994.

- **Hydrochlorofluorocarbons (HCFCs)**, including R22. Slightly less damaging to the ozone than R12, but the EPA has still mandated a phase out as a result of the Clean Air Act of 2010. R22 will phase out completely by 2020.

- **Hydrofluorocarbons (HFCs)**, including R410A and R134. With no chlorine in the mix, this is safer for the environment and is now being used in place of R22. Air conditioners that run on R410A are more efficient, offer better air quality, increase comfort and improve reliability.

Q. Write down Properties of a good refrigerants:

1. Low boiling Point
2. High Critical Temperature
3. High latent heat of vaporisation
4. Low specific heat of liquid
5. Low specific volume of vapour

6. Non-corrosive to metal
7. Non-flammable
8. Non-explosive
9. Non-toxic
10. Low cost
11. Easy to liquify at moderate pressure and temperature
12. Easy to locating leaks by odour or suitable indicator
13. Mixes well with oil.

Q. Write down Classification of Refrigerants:

1. **Primary refrigerants :**
   Primary refrigerants are those working mediums or heat carries which directly take part in the refrigeration system and cool the substance by the absorption of latent heat e.g., Ammonia, Carbon dioride, Sulphur dioxide, Methyl chloride, Methylene chloride, Ethyl chloride and Freon group etc

2. **Secondary refrigerants** :Secondary refrigerants are those circulating substances which are first cooled with the help of The primary refrigerants and are then employed for cooling purposes, e.g., ice, carbondioxide etc. These refrigerants cool substances by absorption of their sensible heat

Q. **Write down types of Primary Refrigerants**

1. **Halocarbon compounds:**
   Halocarbon Compounds refrigerants which contain one or more of three halogens, chlorine and bromine. They are sold in the market under the names as Freon, Genetron, Isotron and Areton. Since the refrigerants belonging to this group have outstanding merits over the group's refrigerants, therefore they find wide field of application in domestic, commercial and industrial purposes.
   Examples: R11,R12, R13,R14, R100, R115

2. Azeotropes:
   The refrigerants are mixtures of different substances. These substances cannot be separated into components by distillation. They possess fired hermodynamic properties and do not undergo any separation with changes in temperature and pressure. An azeotrope behaves like a simple substance.
   Examples: R 500, R502, R503

3. Hydrocarbons:
   Most of the refrigerants of this group are organic compounds. Several hydrocarbons are used successfully in commercial and industrial installations. Most of them possess satisfactory thermodynamic properties but are highly inflammable
   Examples: R50, R170, R290, R600
4. Inorganic compounds :
   Before the introduction of hydrocarbon group these refrigerants were most commonly used for all purposes.

Examples: R717, R718, R744, R764

5. Unsaturated organic compounds:
   The refrigerants belonging to this group possess ethylene or propylene as their constituents.
   Examples: R1120, R1130, R1150, R1270

Q. **What is anti freeze solution?**

An antifreeze is an additive which lowers the freezing point of a water-based liquid. An antifreeze mixture is used to achieve freezing-point depression for cold environments. Common antifreezes also increase the boiling point of the liquid, allowing higher coolant temperature.

Q.**selection of refrigerant for required purpose.**

There are five major factors that design engineers must consider in selecting a refrigerant for a particular application: performance, safety, reliability, environmental acceptability, and simple economics.

1. Environmental acceptability
2. Chemical stability
3. Materials compatibility
4. Refrigeration-cycle performance
5. Adherence to nonflammable and nontoxic guidelines, per Underwriters Laboratories (UL)
6. Boiling point

MCQS:

1. Which of the following is an important factor to consider when selecting a refrigerant?

A) Cost

B) Color

C) Odor

D) Texture

Answer: A) Cost

2. What is a secondary refrigerant used for?

A) Cooling food products

B) Absorbing heat from the primary refrigerant

C) Providing insulation

D) Lubricating compressor parts

Answer: B) Absorbing heat from the primary refrigerant

3. Which of the following is not a factor to consider when selecting a refrigerant for a specific purpose?

A) Environmental impact

B) Efficiency

C) Manufacturer's preference

D) Toxicity

Answer: C) Manufacturer's preference

4. Anti-freeze solutions are commonly used in refrigeration systems to prevent:

A) Overheating

B) Corrosion

C) Freezing

D) Evaporation

Answer: C) Freezing

5. Which refrigerant is known for its ozone-depleting properties and is being phased out globally?

A) R-22

B) R-134a

C) R-410A

D) R-1234yf

Answer: A) R-22

6. When choosing a refrigerant, it is important to consider its global warming potential (GWP) to assess:

A) Cost-effectiveness

B) Environmental impact

C) Efficiency

D) Toxicity

Answer: B) Environmental impact

7. Which of the following refrigerants is commonly used as a replacement for R-22 due to its lower GWP?

A) R-134a

B) R-410A

C) R-404A

D) R-1234yf

Answer: B) R-410A

8. What is the main purpose of selecting a refrigerant for a specific application?

A) To increase energy consumption

B) To minimize environmental impact

C) To maximize noise pollution

D) To enhance system complexity

Answer: B) To minimize environmental impact

9. Which refrigerant is known for its high energy efficiency and is commonly used in residential air conditioning systems?

A) R-22

B) R-134a

C) R-410A

D) R-290

Answer: C) R-410A

10. To prevent health hazards, it is important to choose a refrigerant that has low:

A) Toxicity

B) Viscosity

C) Flammability

D) Conductivity

Answer: A) Toxicity

Unit IV: Application of Refrigerants

Application of Refrigerants: refrigerant oils and applications, Properties and uses of commonly used refrigerant

Q.Write down main types of refrigerant oils

There are two main types of refrigerant oils:

- Mineral Oils, and
- Synthetic Oils

Q. Explain Mineral Oils:

Mineral Oils:
Mineral oils (MO) were first derived from petroleum refining processes. They are produced as a by-product when crude oil is distilled to produce gasoline.

Mineral oil was primarily used with the older generation of refrigerants, including CFCs and HCFCs.

Q. Explain Synthetic Oils

Synthetic Oils
Mineral oils were great for the earlier generations of refrigeration systems with CFCs and HCFCs. As the industry phased out CFCs and HCFCs, it had to develop new oils to use with newer refrigerants.

These new oils are called synthetic oils. Synthetic oils are produced from processed petroleum in order to contain specific properties to work with new refrigerants.
Synthetic oils are required while making retrofits because mineral oils are not miscible with modern refrigerants. This means that mineral oils do not mix well with new refrigerants, which prevents refrigerants from doing their job.

Synthetic oils include:

- Alkylbenzene (AB)
- Polyolester (POE)
- Polyalkylene Glycol - (PAG)
- Polyvinyl Ether (PVE)

Q.Explain Use of synthetic oil
Each of these synthetic oils are used with different refrigerants.
Recall that an oil needs to be miscible with a refrigerant in order for the oil to work in a system containing that refrigerant. For example, let’s say an oil is used in a system with HCFC refrigerant. That means the oil has to be miscible with HCFC refrigerant.

Alkylbenzene (AB) is a synthetic oil used in refrigerant systems with CFC or HCFC refrigerants. As we discussed previously, CFCs and HCFCs have been phased out. But HCFCs are still used in blends.
So, for blends containing HCFCs, we need to use alkylbenzene (AB) to service the system.

Polyolester (POE) is a synthetic oil used in refrigeration systems that contain HFC and HFO refrigerants. These oils are also called ester oils.

Q.Write Properties of a good refrigerants:

1. Low boiling Point.
2. High Critical Temperature.
3. High latent heat of vaporisation.
4. Low specific heat of liquid.
5. Low specific volume of vapour.
6. Non-corrosive to metal.
7. Non-flammable.
8. Non-explosive.

Q.Write Uses of commonly used refrigerant

Refrigerants are used in a direct expansion (DX) system to transfer energy from one environment to another, typically from inside a building to outside (or vice versa) commonly known as an "air conditioner" or "heat pump". Refrigerants can carry per kg 10 times more energy than water and 50 times more than air.

MCQS:

1. Which type of refrigerant oil is most commonly used in air conditioning systems?

a) Mineral oil

b) POE oil

c) PAG oil

d) Alkylbenzene oil

Answer: b) POE oil

2. What is the primary function of refrigerant oil in a refrigeration system?

a) Increase the cooling capacity

b) Lubricate moving parts

c) Remove heat from the system

d) Prevent corrosion

Answer: b) Lubricate moving parts

3. Which refrigerant is commonly used in domestic refrigerators and freezers?

a) R134a

b) R410a

c) R22

d) R12

Answer: a) R134a

4. What is the Ozone Depletion Potential (ODP) of R410a?

a) Zero

b) 0.05

c) 0.85

d) 1.0

Answer: a) Zero

5. Which of the following is a common application of R134a refrigerant?

a) Automotive air conditioning

b) Industrial refrigeration

c) Commercial freezers

d) Residential heat pumps

Answer: a) Automotive air conditioning

6. What is the Global Warming Potential (GWP) of R22 refrigerant?

a) 0

b) 100

c) 500

d) 1810

Answer: d) 1810

7. Which refrigerant is known for its low flammability and toxicity, making it ideal for use in residential air conditioning systems?

a) R32

b) R404a

c) R290

d) R1234yf

Answer: a) R32

8. What is the primary advantage of using R404a refrigerant in industrial refrigeration applications?

a) High energy efficiency

b) Low cost

c) Non-toxicity

d) Low Global Warming Potential

Answer: d) Low Global Warming Potential

9. Which refrigerant is commonly used as a replacement for R22 in existing systems?

a) R134a

b) R407c

c) R410a

d) R123

Answer: b) R407c

10. What is the typical operating pressure range for R410a refrigerant in a residential air conditioning system?

a) 50-100 psi

b) 150-300 psi

c) 400-600 psi

d) 800-1000 psi

Answer: b) 150-300 psi

Unit V: Environmental Effect of Refrigerants

Green house effect, Global warming, Future Refrigerants

Greenhouse Effect Definition

"Greenhouse effect is the process by which radiations from the sun are absorbed by the greenhouse gases and not reflected back into space. This insulates the surface of the earth and prevents it from freezing."

What is the Greenhouse Effect?

A greenhouse is a house made of glass that can be used to grow plants. The sun's radiations warm the plants and the air inside the greenhouse. The heat trapped inside can't escape out and warms the greenhouse which is essential for the growth of the plants. Same is the case in the earth's atmosphere.

During the day the sun heats up the earth's atmosphere. At night, when the earth cools down the heat is radiated back into the atmosphere. During this process, the heat is absorbed by the greenhouse gases in the earth's atmosphere. This is what makes the surface of the earth warmer,that makes the survival of living beings on earth possible.

However, due to the increased levels of greenhouse gases, the temperature of the earth has increased considerably. This has led to several drastic effects.

Let us have a look at the greenhouse gases and understand the causes and consequences of greenhouse effects with the help of a diagram.

What are the Causes of Greenhouse Effect

The major causes of the greenhouse effect are:

Burning of Fossil Fuels

Fossil fuels are an important part of our lives. They are widely used in transportation and to produce electricity. Burning of fossil fuels releases carbon dioxide. With the increase in population, the utilization of fossil fuels has increased. This has led to an increase in the release of greenhouse gases in the atmosphere.

Deforestation

Plants and trees take in carbon dioxide and release oxygen. Due to the cutting of trees, there is a considerable increase in the greenhouse gases which increases the earth's temperature.

Farming

Nitrous oxide used in fertilizers is one of the contributors to the greenhouse effect in the atmosphere.

Industrial Waste and Landfills

The industries and factories produce harmful gases which are released in the atmosphere. Landfills also release carbon dioxide and methane that adds to the greenhouse gases.

Q. What is Global Warming

It is the phenomenon of a gradual increase in the average temperature of the Earth's atmosphere. The main cause for this environmental issue is the increased volumes of greenhouse gases such as carbon dioxide and methane released by the burning of fossil fuels, emissions from the vehicles, industries and other human activities.

Q.Explain Future Refrigerants

Alternatives available today include Hydrocarbons — Isobutane (R-600a), Propane (R-290), and Propylene (R-1270), Ammonia (R-717), and Carbon Dioxide (R-744). Other alternatives such as new HFCs/HFOs are also likely to enter the market in the coming years.

MCQS:

1. Which environmental issue is primarily caused by the release of refrigerants containing chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)?

A) Ozone depletion

B) Global warming

C) Acid rain

D) Deforestation

Answer: A) Ozone depletion

2. The greenhouse effect is enhanced by the emissions of which type of refrigerant?

A) CFCs

B) HCFCs

C) HFCs

D) Ammonia

Answer: C) HFCs

3. What is the main gas responsible for trapping heat in the atmosphere and contributing to global warming?

A) Carbon monoxide

B) Nitrous oxide

C) Methane

D) Carbon dioxide

Answer: D) Carbon dioxide

4. Which of the following future refrigerants is considered a more environmentally friendly alternative to traditional HFCs?

A) R-22

B) R-410A

C) R-134a

D) R-744 (Carbon dioxide)

Answer: D) R-744 (Carbon dioxide)

5. Which refrigerant has the highest Global Warming Potential (GWP) among commonly used refrigerants?

A) R-22

B) R-410A

C) R-134a

D) R-32

Answer: B) R-410A

6. The reduction of which type of refrigerant is regulated by the Montreal Protocol due to its harmful effects on the ozone layer?

A) CFCs

B) HCFCs

C) HFCs

D) Ammonia

Answer: A) CFCs

7. Which environmental issue is associated with the leakage of refrigerants into the atmosphere?

A) Coral bleaching

B) Ocean acidification

C) Deforestation

D) Global warming

Answer: D) Global warming

8. What is the primary goal of transitioning to alternative refrigerants with lower GWP values?

A) Protecting marine life

B) Preserving biodiversity

C) Mitigating climate change

D) Promoting sustainable agriculture

Answer: C) Mitigating climate change

9. Which refrigerant is commonly used in refrigeration systems due to its low toxicity and flammability?

A) Ammonia

B) Propane

C) R-134a

D) R-410A

Answer: A) Ammonia

10. How do HFCs contribute to the greenhouse effect and global warming?

A) By depleting the ozone layer

B) By trapping heat in the atmosphere

C) By causing acid rain

D) By leading to deforestation

Answer: B) By trapping heat in the atmosphere