

REFRIGERATION AND AIRCONDITIONING SYSTEM REFRIGERATION

Need for refrigeration

- In hotels and households, food items ,both cooked and uncooked, can be preserved for a long time in low temperatures.
- Storage of fruits and vegetables makes it possible to add fresh salads to them en year round.
- Storage of fish, meat and other perishables items safely for longer periods is possible due to refrigeration.
- Seasonal food item scan be bought from tin bulk quantity at relatively cheaper price, stored unrefrigerated conditions and later used during offseason.
- Cooling of dessert sand drinks.

What isrefrigeration?Andusefuldefinitions

Refrigeration is the science of producing and maintaining a temperature condition in a closed spacelowerthanthesurroundingambiancebyremovingheatfromthespace andtransferring that heat to another space or substance.

TERMS USED IN REFRIGERATION:

- **REFRIGERANT**– It isthesubstanceusedforheattransferinarefrigerationsystem. It takes up heat from inside the refrigerator cabinet and releases it to outside atmosphere.
- **SENSIBLEHEAT**– T

the heat which is used to raise or lower the temperature of a substance.

- **LATENT HEAT**– Latent heat is the energy absorbed or released when a substance changes its physical state. Latent heat is absorbed upon evaporation, and released upon condensation to liquid (as in clouds).
- **EVAPORATION**– It is the process of a substance in a liquid state changing to a gaseous state due to an increase in temperature and/or pressure.
- **CONDENSATION**- It is the change of the physical state of matter from gas phase into liquid phase, and is the reverse of evaporation.
- **ONE TON OF REFRIGERATION**– It means cooling by extracting heat at the rate of 50 Kcal/minute or 3000 Kcal/hr.

Types of refrigerants and usage

APPLICATION	REFRIGERANTS
Refrigerator	R ₁₂ , R ₂₂ (CFC)
Food Freezers	R ₁₂ , R ₂₂ , R ₅₀₂ (HCFC in gaseous state)
Air Conditioning	R ₁₂
Frozen Food Delivery System	R ₂₂ , Dry Ice (R ₇₄₄)
Ice Plants	Solid Carbon Dioxide (R ₇₄₄), Ammonia (R ₇₁₇)

Desirable properties of refrigerant

The main components of a refrigeration process are:

1. Evaporator
2. Compressor
3. Condenser

4. Expansion Valve

EVAPORATOR: In the evaporator the Refrigerant absorbs the heat from the object to be cooled and itself gets heated up. The heat absorbed is the latent heat of vaporization of the liquid refrigerant and therefore the refrigerant undergoes a change of state i.e. from liquid to vapours without any change in temperature. The vapour refrigerant then returns to the compressor.

COMPRESSOR: The vapour refrigerant is compressed at a very high pressure and temperature. It then passes through the condenser coil.

CONDENSER: While passing through the condenser the refrigerant rejects heat either to air or to surrounding water which get sheeted up. The refrigerant condenses to cold liquid state but at high pressure. This high pressure colder refrigerant then passes through the expansion valve.

EXPANSION VALVE:

The expansion valve cools down the refrigerant to a low temperature and also

reduces the pressure.

It can be adjusted to control the temperature and pressure to which the refrigerant goes to the evaporator.

Cool refrigerant is now ready to absorb heat in the Evaporator.

*Efficiency of Refrigeration System is expressed (COP) and is defined as the ratio of refrigeration effect produced to the mechanical work done.

REFRIGERATION CYCLE

To avoid continuous running

Of electric motor (motor required to run the compressor) and unnecessary work of compression, thermostatic control is used which senses the interior temperature and stops the motor from running and when the temperature rises again, the motor restarts and the Compressor starts working again.

Compressor is the most expensive part of the refrigeration cycle and its repair is difficult. An inefficient or defective compressor is generally replaced with a new one.

Ideal Cycle

An **Ideal Cycle** is a theoretical thermodynamic cycle in which all processes occur under ideal conditions without friction, heat losses, pressure drops, or other irreversibilities. It is used to analyze and compare the performance of engines, turbines, refrigerators, and compressors.

Characteristics of an Ideal Cycle

1. All processes are reversible.
2. No frictional losses occur.
3. Heat transfer takes place under ideal conditions.
4. Working fluid returns to its initial state after one complete cycle.
5. Maximum possible efficiency is obtained.

Common Ideal Cycles

- **Otto Cycle** – Ideal cycle for petrol (SI) engines.
- **Diesel Cycle** – Ideal cycle for diesel (CI) engines.
- **Dual Cycle** – Combination of Otto and Diesel cycles.
- **Brayton Cycle** – Ideal cycle for gas turbines.
- **Rankine Cycle** – Ideal cycle for steam power plants.
- **Carnot Cycle** – Most efficient theoretical heat engine cycle.

Carnot Cycle

The ideal heat engine cycle is:

$$\eta = 1 - \frac{T_L}{T_H}$$

Where:

- η = Thermal efficiency
- T_H = Temperature of heat source
- T_L = Temperature of heat sink

Advantages

- Provides maximum theoretical efficiency.
- Helps compare actual engine performance.
- Simplifies thermodynamic analysis.

Applications

- Internal combustion engines.
- Gas turbines.
- Steam power plants.
- Refrigeration and air-conditioning systems.

2. Effect of Operating Parameters on Expansion Valve

Parameter

Effect on Expansion Valve

Condenser Pressure Higher pressure increases refrigerant flow rate.

**Effect of
Operating**

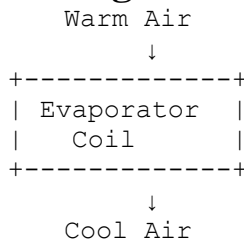
Parameters on Evaporator

The **evaporator** is the component where the refrigerant absorbs heat from the space to be cooled.

Operating Parameters and Their Effects

Parameter	Effect on Evaporator
Evaporator Temperature	Lower temperature increases cooling but reduces COP.
Refrigerant Flow Rate	Higher flow rate increases heat absorption capacity.
Air Flow Rate	Increased airflow improves heat transfer and cooling efficiency.
Evaporator Pressure	Lower pressure lowers refrigerant boiling temperature.
Frost Formation	Excess frost reduces heat transfer and cooling performance.

Diagram



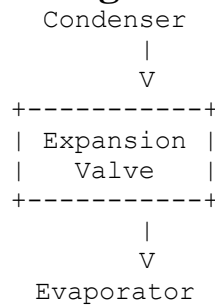
Operating Parameters and Their Effects

Evaporator Pressure	Lower pressure increases valve opening.
Superheat Setting	Higher superheat reduces refrigerant flow.
Refrigerant Type	Different refrigerants require different valve settings.
Load Variation	Increased cooling load causes greater valve opening.

Functions

- Controls refrigerant flow.
- Maintains proper evaporator pressure.
- Produces pressure drop for refrigeration effect.

Diagram



3. Refrigerant Properties

A **refrigerant** is the working fluid used in refrigeration and air-conditioning systems.

Desirable Properties of Refrigerants

Physical Properties

- Low boiling point.
- High latent heat of vaporization.
- Low freezing point.
- High thermal conductivity.

Chemical Properties

- Non-toxic.
- Non-flammable.
- Non-corrosive.
- Chemically stable.

Environmental Properties

- Zero Ozone Depletion Potential (ODP).

- Low Global Warming Potential (GWP).

1. ODP (Ozone Depletion Potential)

Definition:

ODP is a measure of how much a refrigerant can damage the Earth's ozone layer compared to CFC-11, which has an ODP value of 1.

2. GWP (Global Warming Potential)

Definition:

GWP measures how much heat a greenhouse gas traps in the atmosphere compared to carbon dioxide (CO₂), which has a GWP value of 1.

Loading of Vapour Compression Refrigeration (VCR) Definition

Loading of a Vapour Compression Refrigeration (VCR) Unit refers to the amount of heat that must be removed from a refrigerated space to maintain the desired temperature.

The load on the refrigeration system determines the required cooling capacity of the evaporator, compressor, condenser, and other components.

Types of Refrigeration Loads

1. Product Load

Heat removed from the product being cooled.

2. Transmission Load

Heat entering through walls, roof, floor, doors, and windows due to temperature difference.

3. Infiltration Load

Heat entering when warm outside air leaks into the refrigerated space through door openings or cracks.

4. Internal Load

Heat generated inside the refrigerated space by:

- Lights
- Motors
- Fans
- Workers

5. Equipment Load

Heat produced by machinery and electrical equipment operating inside the cooled area.

Factors Affecting Refrigeration Load

- Size of refrigerated space
- Outside temperature
- Number of door openings
- Quantity of stored products
- Number of occupants
- Insulation quality
- Lighting and equipment usage

Refrigeration Capacity

The refrigeration effect is:

$$Q_L = m(h_1 - h_4)$$

Where:

- Q_L = Refrigeration load (kW)
- m = Mass flow rate of refrigerant (kg/s)

- h_1 = Enthalpy at evaporator outlet
- h_4 = Enthalpy at evaporator inlet

Compound Compression in Refrigeration Definition

Compound Compression is a refrigeration process in which the refrigerant vapor is compressed in **two or more stages** instead of a single stage. It is used when a large pressure difference exists between the evaporator and condenser.

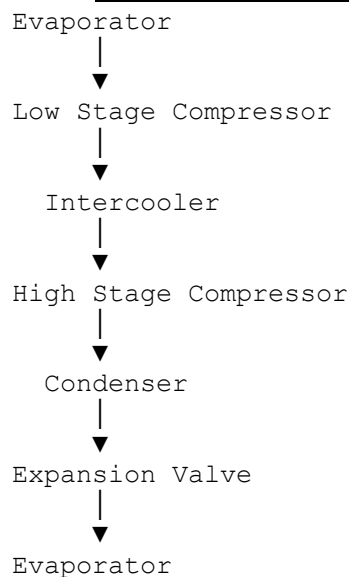
Need for Compound Compression

- Reduces compressor work.
- Improves Coefficient of Performance (COP).
- Lowers discharge temperature.
- Increases volumetric efficiency.
- Suitable for very low-temperature refrigeration applications.

Working Principle

1. Low-pressure refrigerant vapor from the evaporator enters the **low-stage compressor**.
2. It is compressed to an intermediate pressure.
3. The vapor is cooled in an **intercooler**.
4. The cooled vapor enters the **high-stage compressor**.
5. It is compressed to condenser pressure.
6. The high-pressure vapor is condensed in the condenser.
7. Refrigerant passes through expansion valve and evaporator to complete the cycle.

Simple Diagram



Advantages

- Higher refrigeration efficiency.
- Reduced power consumption.
- Lower compressor discharge temperature.

- Better lubrication and compressor life.
- Suitable for large industrial refrigeration plants.

Applications

- Cold storage plants.
- Ice manufacturing plants.
- Food freezing units.
- Chemical industries.
- Low-temperature refrigeration systems.

Conclusion

Compound compression is a multi-stage compression process used in refrigeration systems to achieve high pressure ratios efficiently, improve COP, reduce compressor work, and provide reliable operation at low temperatures.

FLAS INTERCOOLING-FLASH CHAMBER-MULTI-EVAPORATOR AND MULTISTAGE SYSTEMS

1. Flash Intercooling

Definition

Flash intercooling is a method used in multi-stage refrigeration systems where the refrigerant is cooled between compression stages using a flash chamber.

Working

1. Refrigerant from the condenser is expanded to an intermediate pressure.
2. Part of the liquid refrigerant evaporates (flash gas).
3. The flash gas cools the refrigerant vapor coming from the low-stage compressor.
4. The cooled vapor enters the high-stage compressor.

Advantages

- Improves COP.
- Reduces compressor work.
- Lowers discharge temperature.
- Increases refrigeration effect.

Applications

- Large industrial refrigeration plants.
- Cold storage systems.

- Ice manufacturing plants.

2. Flash Chamber

Definition

A flash chamber is a vessel used to separate liquid refrigerant from flash vapor formed during throttling.

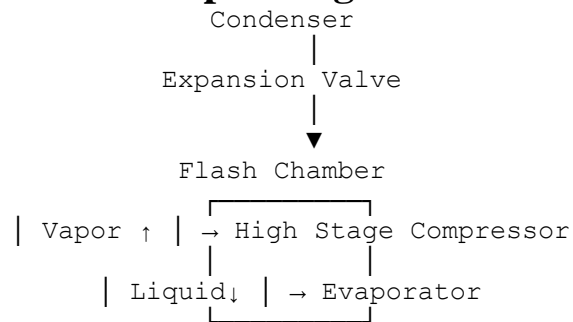
Functions

- Separates liquid and vapor refrigerant.
- Provides intercooling between compressor stages.
- Supplies liquid refrigerant to the evaporator.

Working Principle

- High-pressure liquid refrigerant is throttled to intermediate pressure.
- Some liquid evaporates instantly (flash gas).
- Vapor is separated at the top.
- Liquid collects at the bottom and flows to the evaporator.

Simple Diagram



3. Multi-Evaporator System

Definition

A refrigeration system having two or more evaporators operating at different temperatures from a single compressor unit.

Working

- Refrigerant from the condenser is distributed to multiple evaporators.
- Each evaporator provides cooling at a different temperature.
- Refrigerant vapor from all evaporators returns to the compressor.

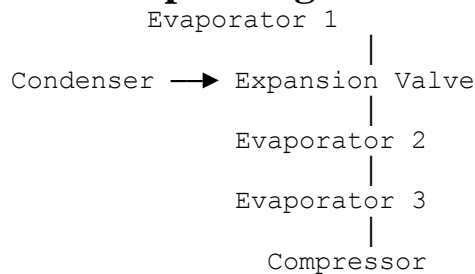
Advantages

- Different cooling temperatures can be maintained.
- Better utilization of refrigeration capacity.
- Energy efficient.

Applications

- Supermarkets.
- Food processing plants.
- Hotels and hospitals.
- Large cold storage facilities.

Simple Diagram



4. Multi-Stage Refrigeration System

Definition

A refrigeration system in which compression is carried out in two or more stages with intercooling between stages.

Working

1. Low-stage compressor compresses refrigerant vapor.
2. Intercooler reduces vapor temperature.
3. High-stage compressor compresses vapor to condenser pressure.
4. Refrigerant condenses and expands through the expansion valve.
5. Refrigeration effect is produced in the evaporator.

Advantages

- Higher efficiency.
- Lower power consumption.
- Reduced discharge temperature.
- Suitable for low-temperature applications.

Applications

- Ice plants.
- Frozen food storage.
- Chemical industries.
- Pharmaceutical industries.

Simple Diagram

