Chapter 5 – Thermal Systems Applications

Session 1 – Refrigeration Definition, Refrigerant, Vapor Compression Refrigeration, Properties of good refrigerant, Performance characteristics of refrigeration system.

Topic Learning Outcomes:

1. Explain the working principle of Refrigeration system

2 Describe the working principle of Air conditioning system

3 Outline the working of a pump & blower

4 Describe the functioning of an air compressor


Refrigeration

Contents of this session

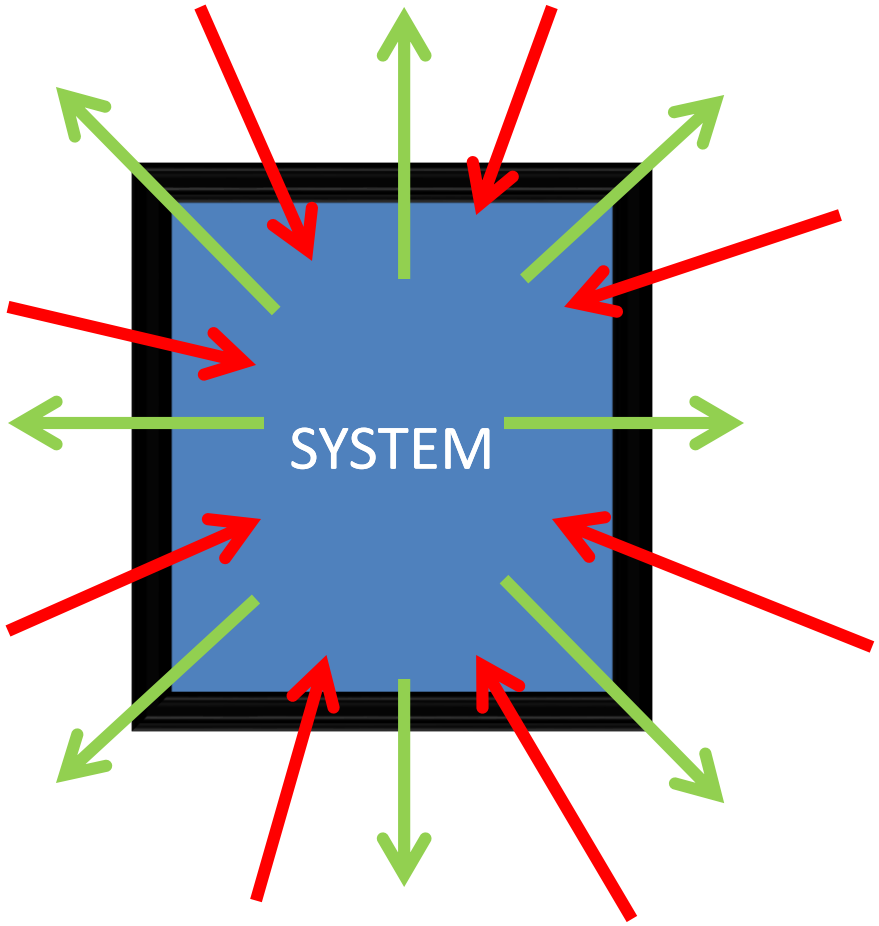
1. Introduction to refrigeration
2. Definition
3. Refrigerant
4. Types of refrigerant
5. Vapor Compression Refrigeration
6. Air Conditioning system
7. Properties of good refrigerant
8. Performance characteristics of a refrigeration system.

Introduction

Definition

- Refrigeration is defined as a method of reducing the temperature of a system below that of the surroundings and maintain it at the lower temperature by continuously abstracting the heat from it.

Principle of Refrigeration



SURROUNDING

Continuous Power to the system

Refrigerant

- In a refrigerator, a medium called refrigerant continuously extracts the heat from the space within the refrigerator which is to be kept cool at temperatures less than the atmosphere.

- Some examples are :

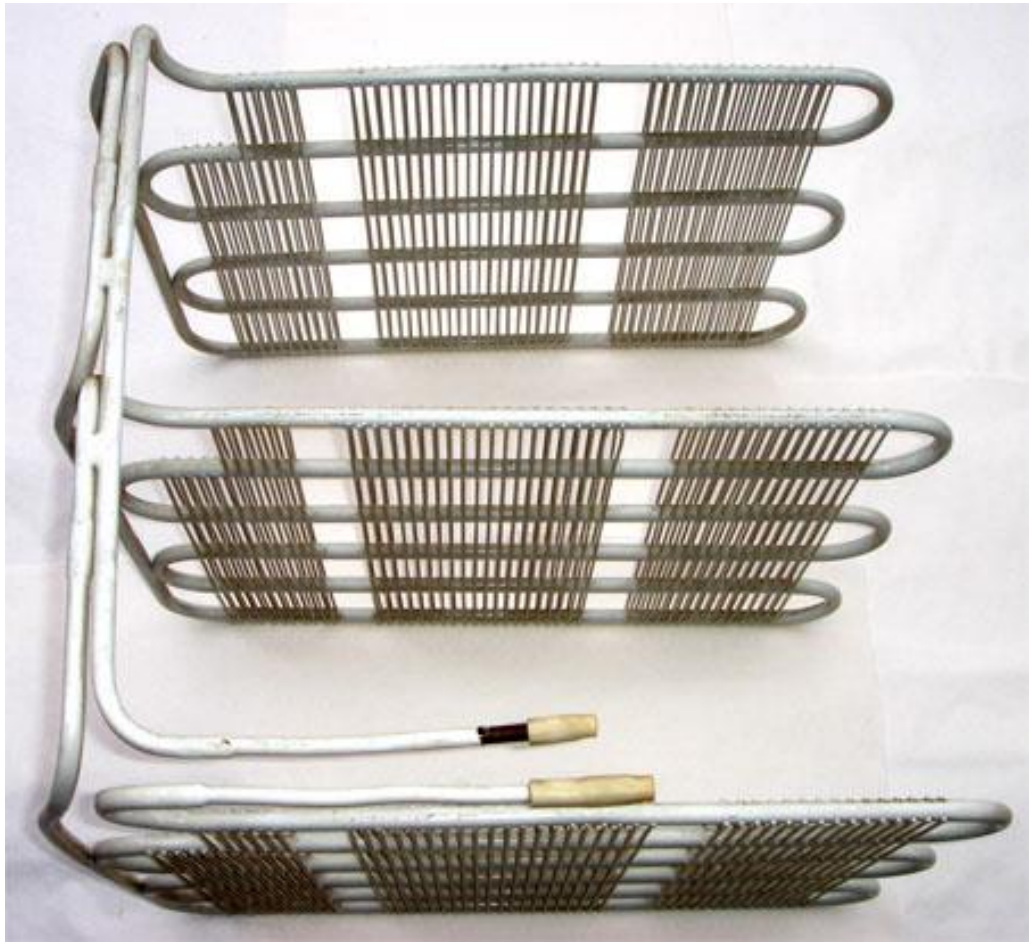
- Ammonia.
- Freon.
- Methyl Chloride.
- Carbon Dioxide.

Parts of a Refrigerator

- Evaporator.
- Condenser.
- Expansion Device.
- Circulating System

Parts of a Refrigerator

- Evaporator.



Parts of a Refrigerator

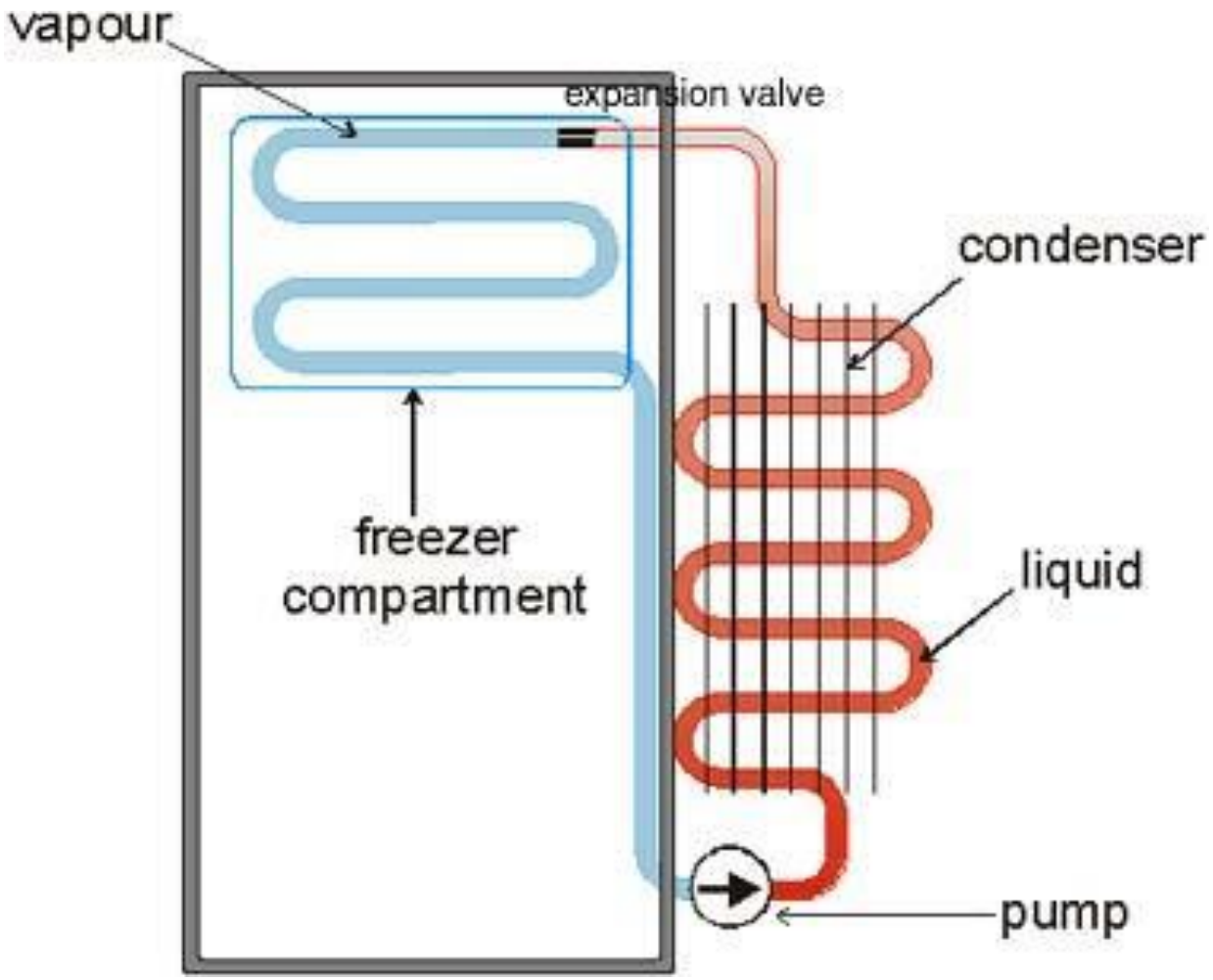
- Condenser.

Parts of a Refrigerator

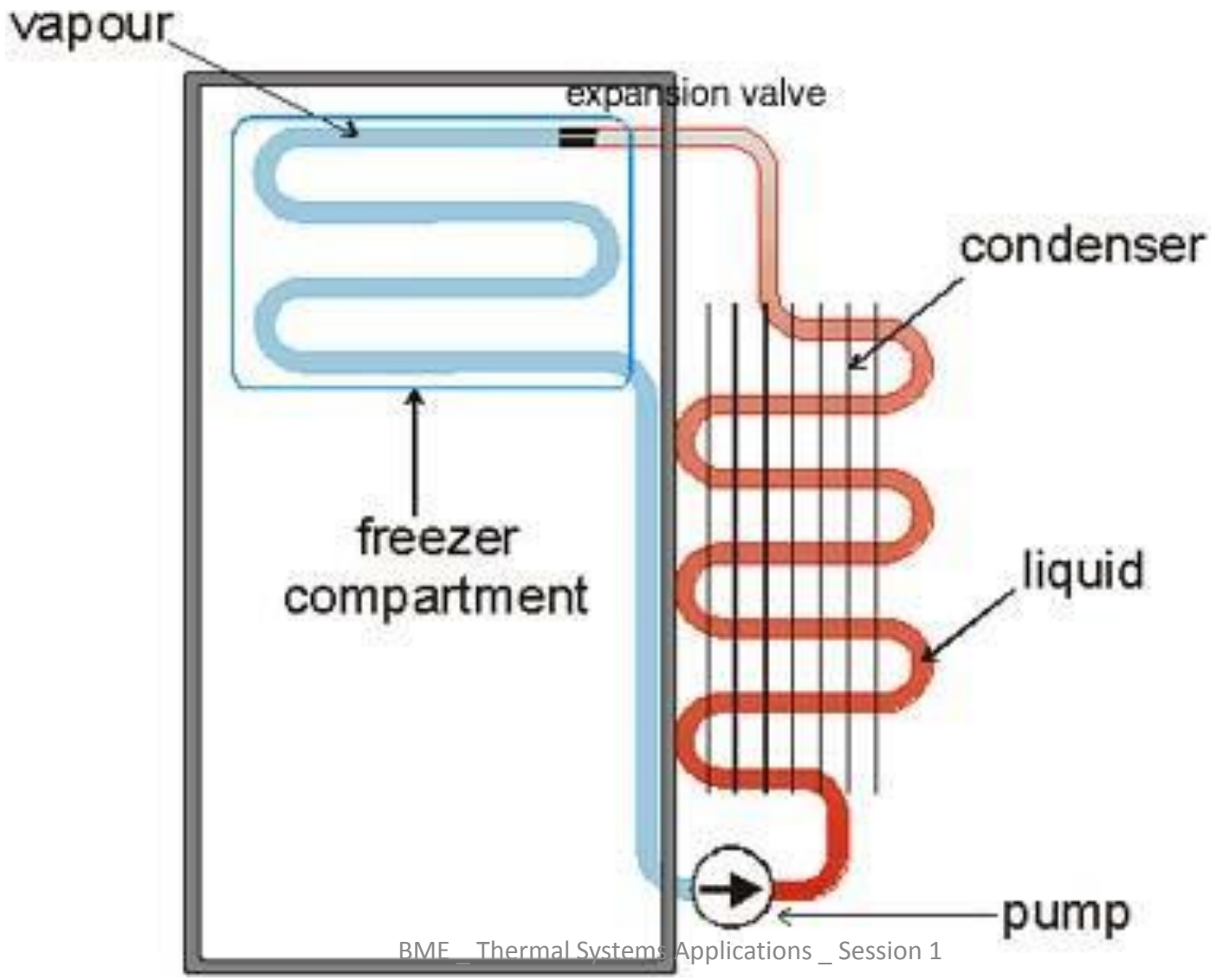
- Expansion device.

Parts of a Refrigerator

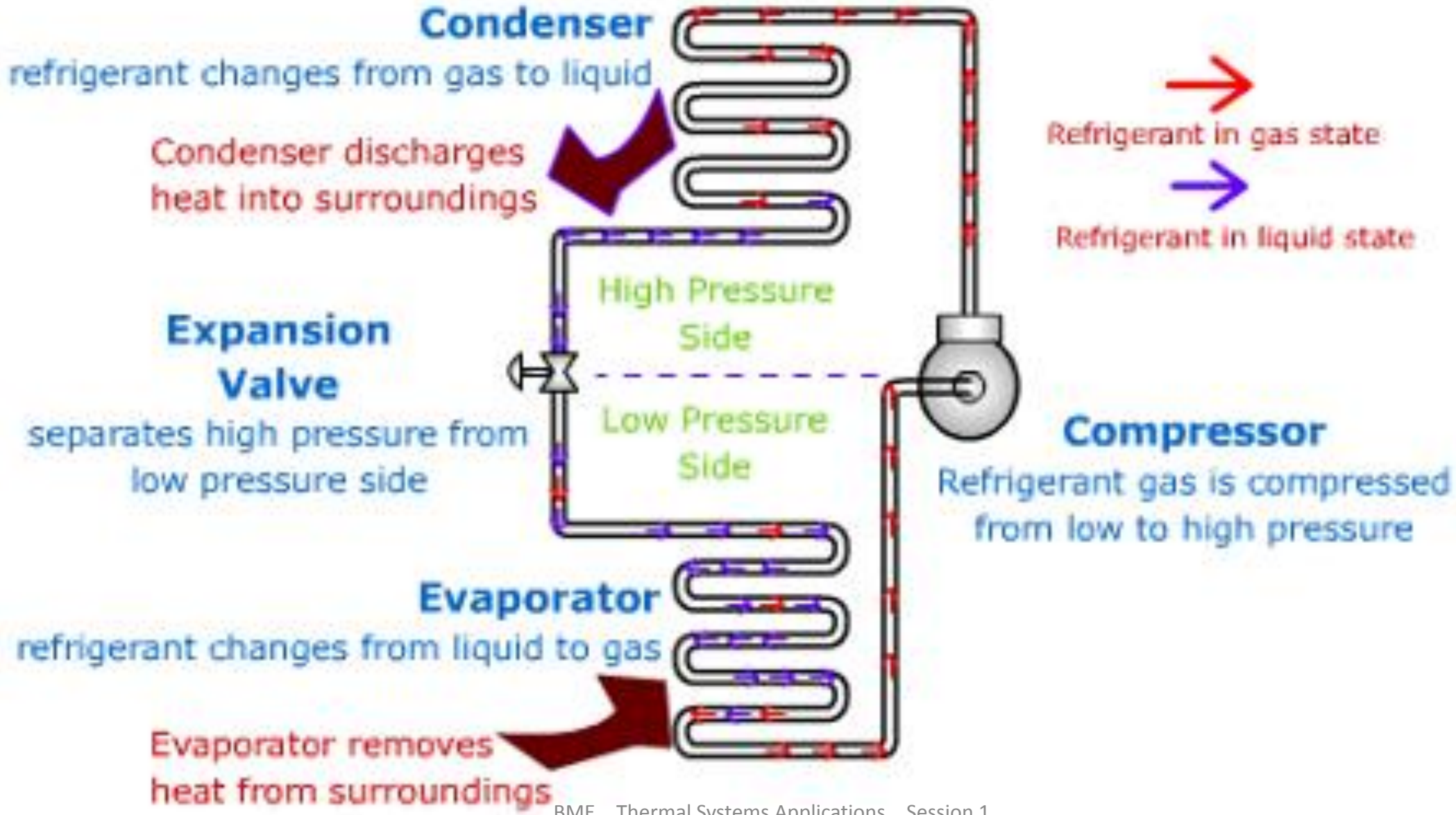
- Circulating system



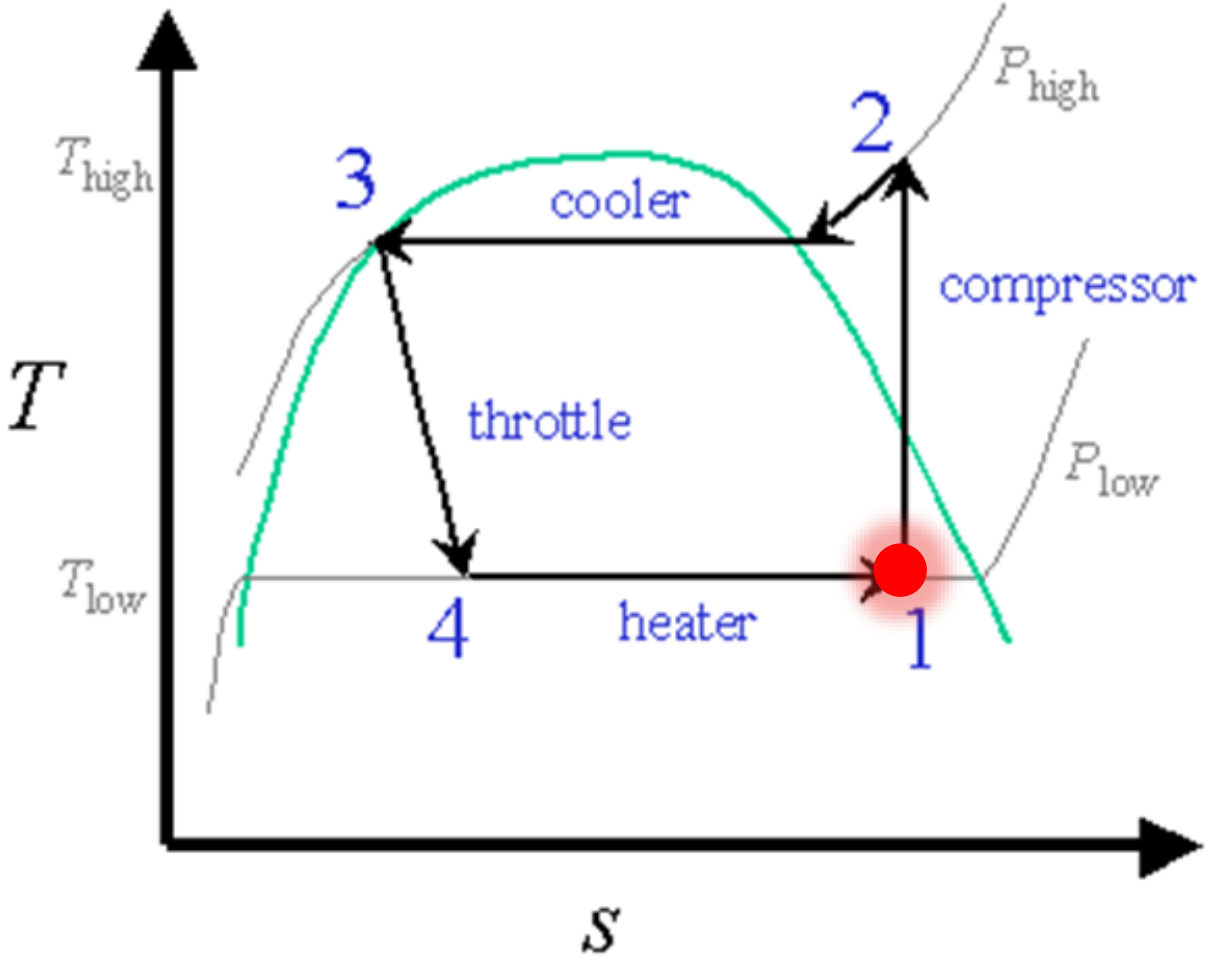
Vapor Compression Refrigeration

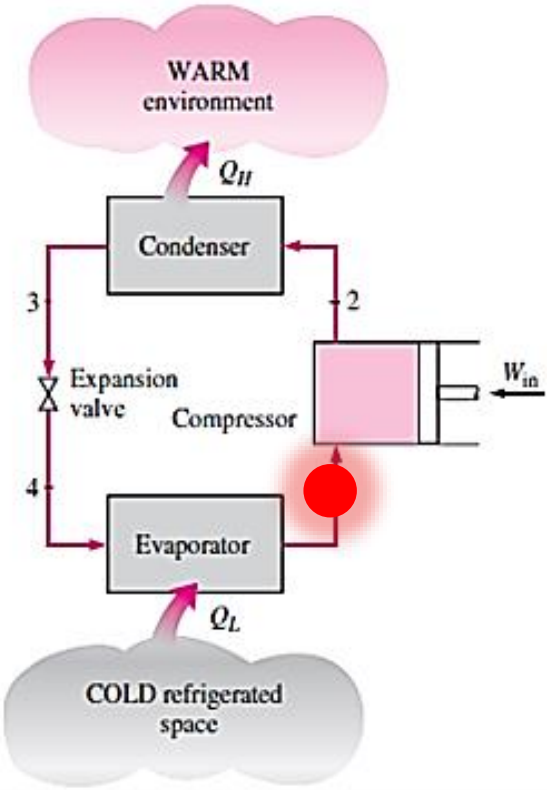


Vapor Compression Refrigeration System

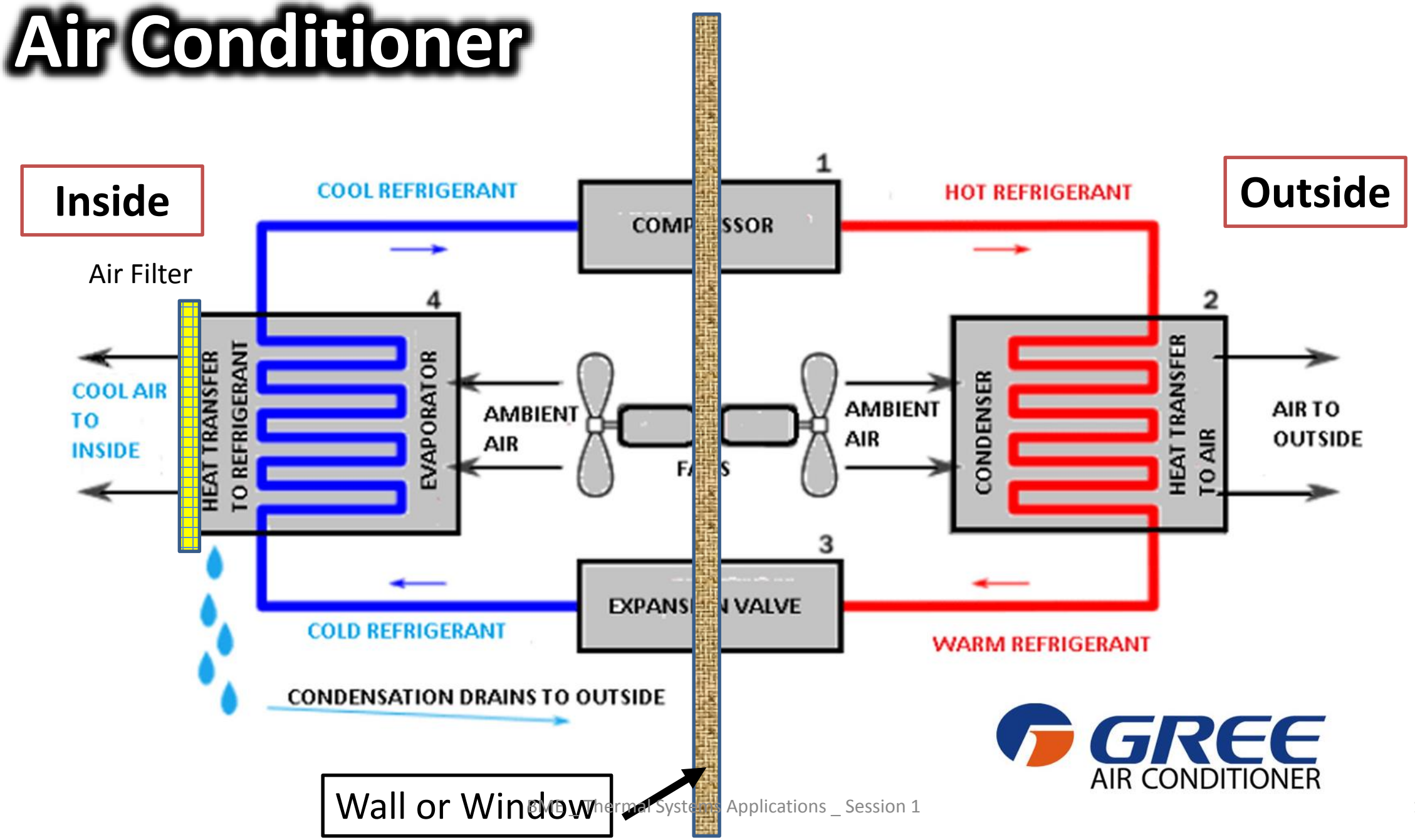


Vapor Compression Refrigeration





Air Conditioner



Properties of a Good Refrigerant:

Thermodynamic Properties	Physical Properties	Safe Working Properties	Other Properties
1. Boiling Point. 2. Freezing Point 3. Evaporator and condenser Pressure. 4. Latent heat of evaporation.	1. Specific Volume. 2. Specific Heat. 3. Viscosity.	1. Toxicity. 2. Flammability. 3. Corrosiveness. 4. Chemical Stability.	1. COP. 2. Odour. 3. Leak. 4. Action with lubricating oil.

Properties of a Good Refrigerant:

Thermodynamic Properties

1. **Boiling Point.**
2. **Freezing Point**
3. **Evaporator and condenser Pressure.**
4. **Latent heat of evaporation.**

An Ideal refrigerant should have low boiling temperature at atmospheric pressure.

An ideal refrigerant must have a very low freezing point because the refrigerant should not freeze at low evaporator temperatures.

In order to avoid leakage of the atmospheric air and also to enable detection of leakage of refrigerant, both the evaporator and condenser pressure should be slightly above the atmospheric pressure.

The latent heat of vaporization must be very high so that a minimum amount of refrigerant will accomplish the desired result.

Properties of a Good Refrigerant:

Physical Properties

1. **Specific Volume.**
2. **Specific Heat.**
3. **Viscosity.**

The specific volume of a refrigerant must be very low. Lower the specific volume of the refrigerant at the suction of compressor reduces the size of compressor.

A good refrigerant should have low specific heat when it is in liquid state and high specific heat when it is vaporized. The low specific heat of refrigerant helps in sub cooling of liquid and high specific heat of vapor helps in decreasing the superheating of the vapor.

The viscosity of a refrigerant at both liquid and vapor states must be very low as it improves the heat transfer and reduces the pumping pressure.

Properties of a Good Refrigerant:

Safe Working Properties

1. **Toxicity.**
2. **Flammability.**
3. **Corrosiveness.**
4. **Chemical Stability.**

A good refrigerant should be non toxic.

A good refrigerant should be non flammable.

A good refrigerant must be non corrosive.

An ideal refrigerant must not decompose under operating conditions.

Properties of a Good Refrigerant:

Other Properties

1. **COP.**
2. **Odour.**
3. **Leak.**
4. **Action with lubricating oil.**

The COP of a refrigerator should be high so that the energy spent in refrigeration will be less.

A good refrigerant should be odorless.

The refrigerants must be such that any leakage can be detected by simple tests.

A good refrigerant must not react with the lubricating oil.

PERFORMANCE CHARACTERISTICS OF REFRIGERATION SYSTEM

Refrigeration Effect

- In a refrigeration system, the rate at which the heat is absorbed in a cycle from the interior space to be cooled is called refrigeration effect.

Capacity of Refrigeration

- The capacity of refrigeration is expressed in terms of tons of refrigeration which is the unit of refrigeration.

A ton of refrigeration is defined as the quantity of heat absorbed in order to form one ton of ice in 24 hrs when the initial temperature is 0^oC.

One (American) ton = 2000 pounds

In SI System,

1 ton of Refrigeration = 210 kJ/min

= 3.5 kW

Ice Making Capacity

Ice making capacity is defined as the capacity of the refrigerating system to make ice beginning from water at room temperature to solid ice.

It is usually specified in kJ/Hr.

Coefficient of Performance

The COP of a refrigeration system is defined as the ratio of heat absorbed in a system to the work supplied.

$$COP = \frac{Q}{W}$$

Q = Heat absorbed or removed.

W = Work Supplied.

Relative Coefficient of Performance

The ratio of actual COP to the Theoretical COP is known as Relative COP

$$Relative\ COP = \frac{Actual\ COP}{Theoretical\ COP}$$

Chapter 5 – Thermal Systems Applications

Session 2 – Pumps, blowers and compressors, Positive displacement machines, Turbo machines, Lobe pump, Gear pump, Scroll pump, Screw pump, Vane pump and Centrifugal compressor

Topic Learning Outcomes:

1. Explain the working principle of Refrigeration system

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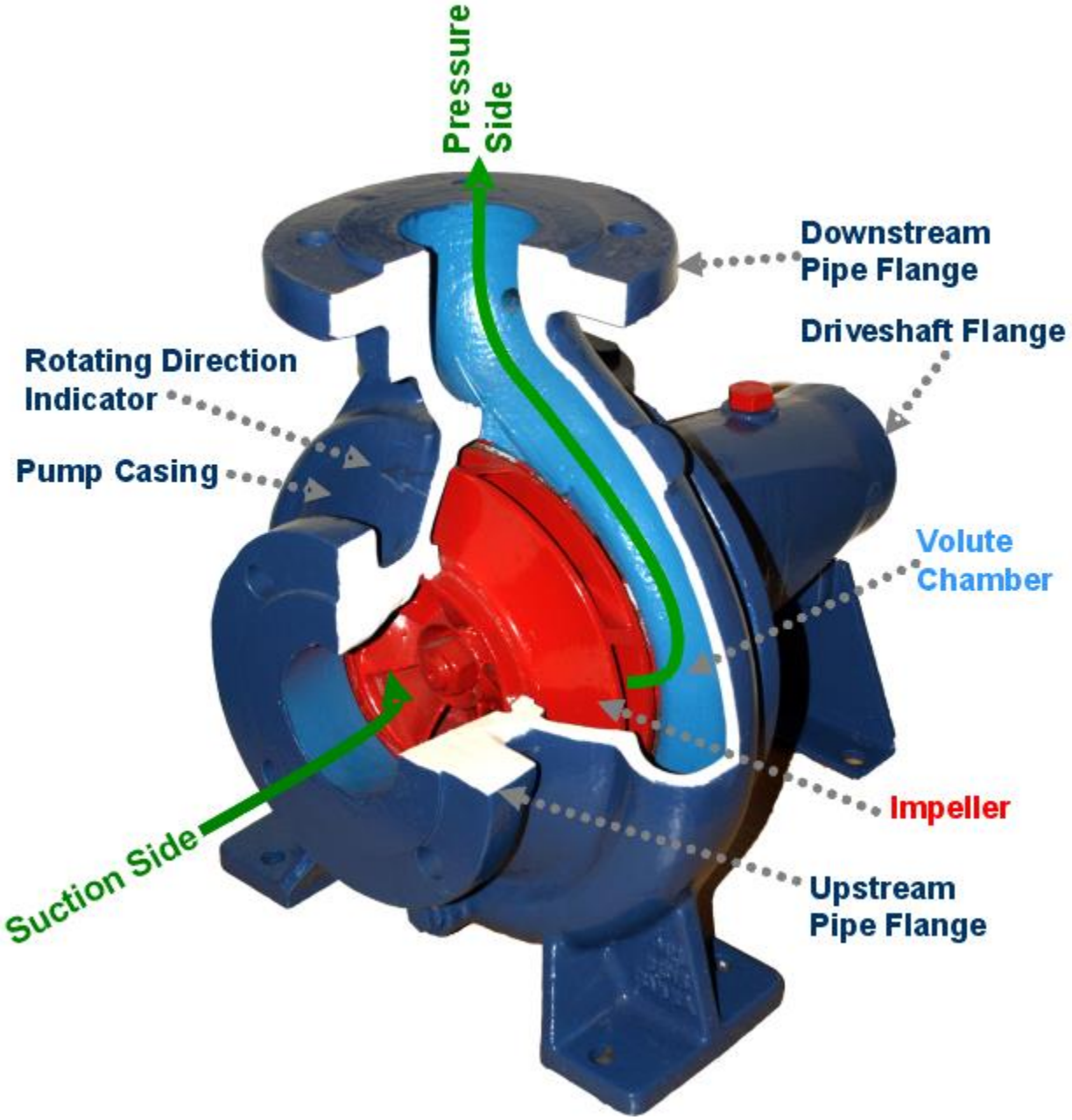
Content

1. Definition
2. Pump, Blower and compressor
3. Positive displacement machines
4. Dynamic or Turbo Machines
5. Gear Pump
6. Screw Pump
7. Scroll Pump
8. Lobe Pump
9. Vane Pump
10. Centrifugal Compressor

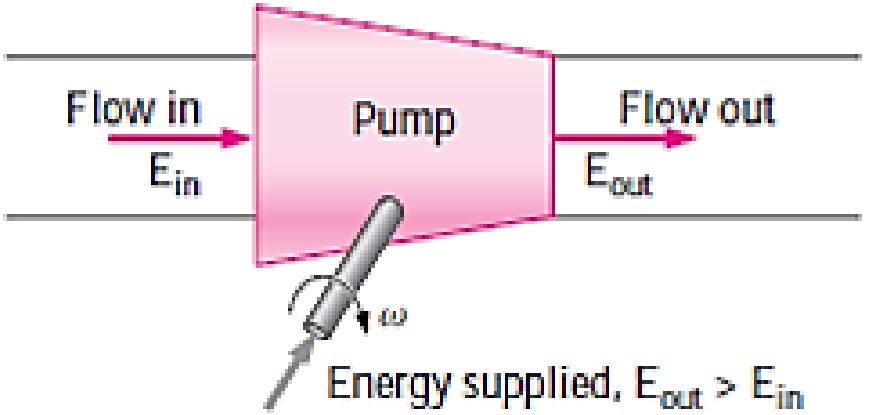
Definition

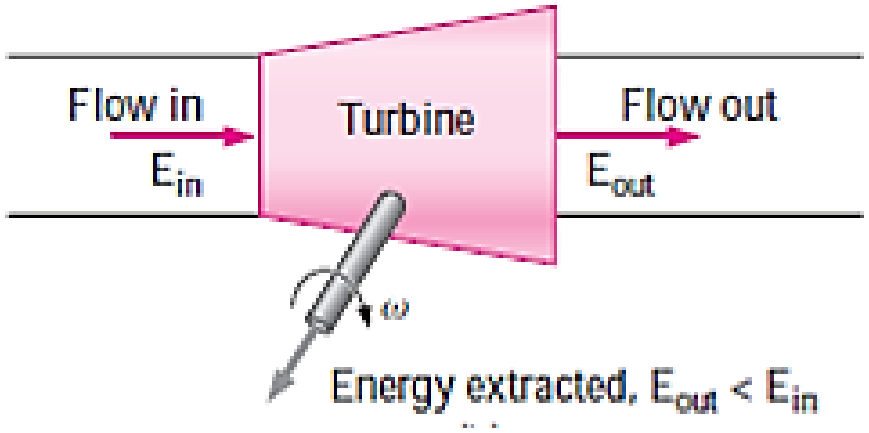
A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into Hydraulic energy.

PUMPS


Pressure Side
Downstream Pipe Flange
Driveshaft Flange
Rotating Direction Indicator
Pump Casing
Volute Chamber
Impeller
Suction Side
Upstream Pipe Flange

The purpose of a pump is to add energy to a fluid, resulting in an increase in fluid pressure, not necessarily an increase of fluid speed across the pump.





The purpose of a turbine is to extract energy from a fluid, resulting in a decrease of fluid pressure, not necessarily a decrease of fluid speed across the turbine.

A fan is a gas pump with relatively low pressure rise and high flow rate. Examples include ceiling fans, house fans, and propellers.

A blower is a gas pump with relatively moderate to high pressure rise and moderate to high flow rate. Examples include centrifugal blowers and squirrel cage blowers in automobile ventilation systems, furnaces, and leaf blowers.

A compressor is a gas pump designed to deliver a very high pressure rise, typically at low to moderate flow rates. Examples include air compressors that run pneumatic tools and inflate tires at automobile service stations, and refrigerant compressors used in heat pumps, refrigerators, and air conditioners.

Difference between Fan, Blower and Compressor

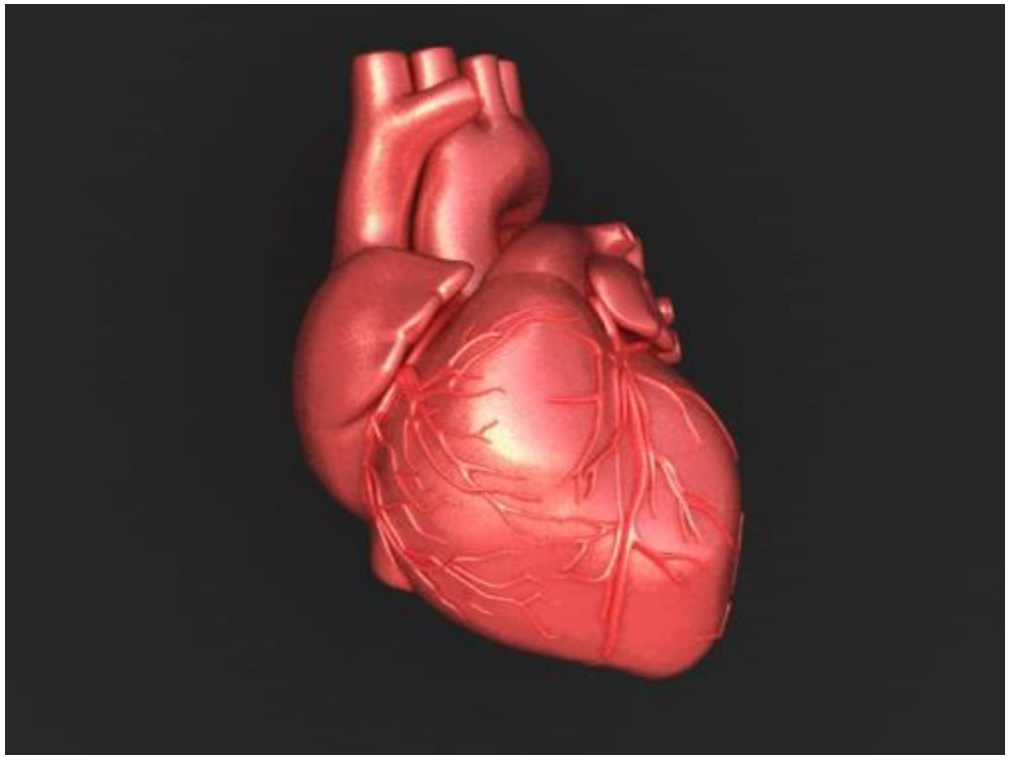
	Fan	Blower	Compressor
ΔP	Low	Medium	High
$\dot{V}$	High	Medium	Low

ΔP = Rise in pressure

$\dot{V}$ = Discharge rate

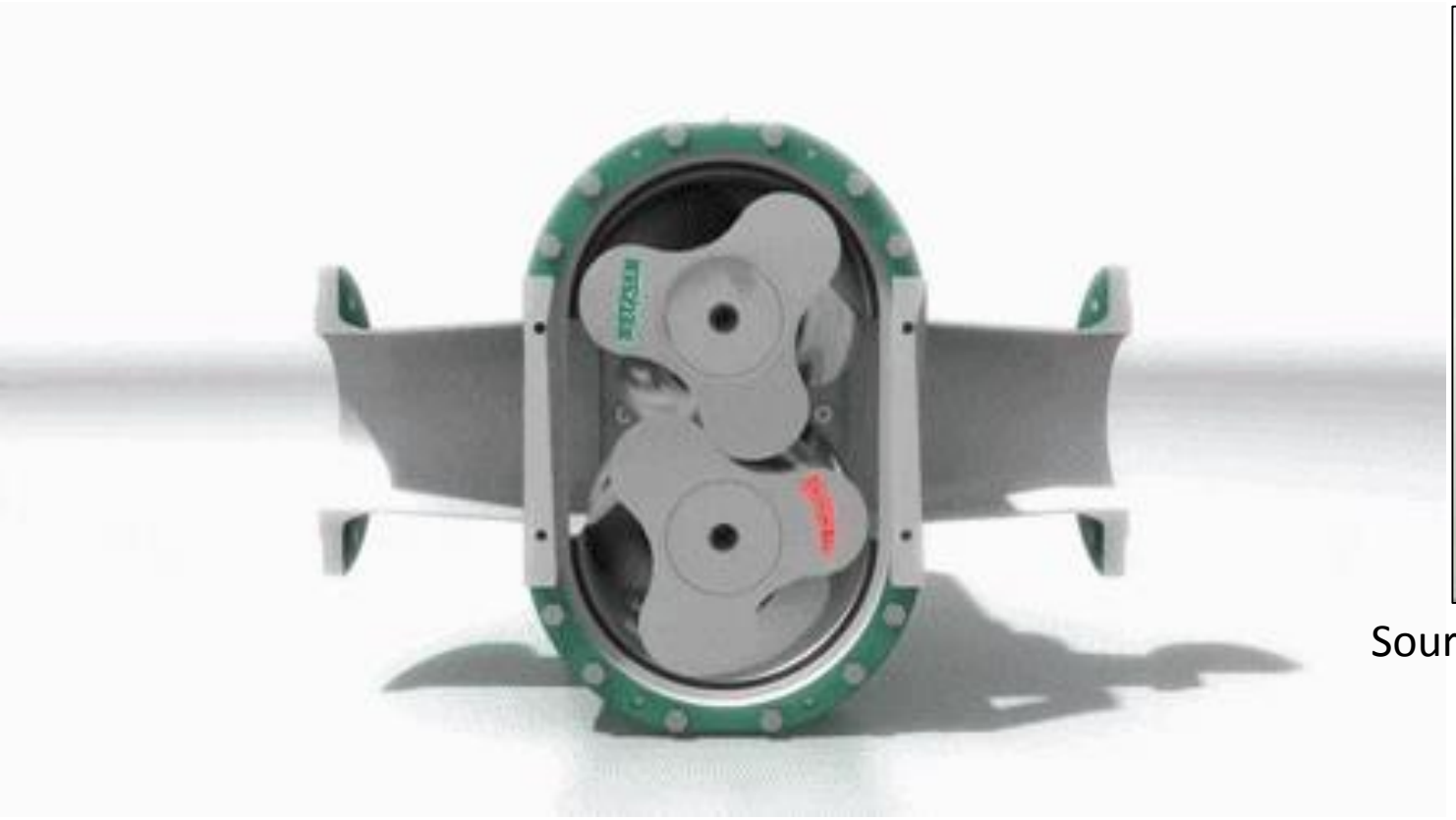
Pumps and turbines in which energy is supplied or extracted by a rotating shaft are properly called turbo machines or dynamic machines. In dynamic machines, there is no closed volume; instead, rotating blades supply or extract energy to or from the fluid.

In positive-displacement machines, fluid is directed into a closed volume. Energy transfer to the fluid is accomplished by movement of the boundary of the closed volume, causing the volume to expand or contract, thereby sucking fluid in or squeezing fluid out, respectively.



Positive Displacement Pumps

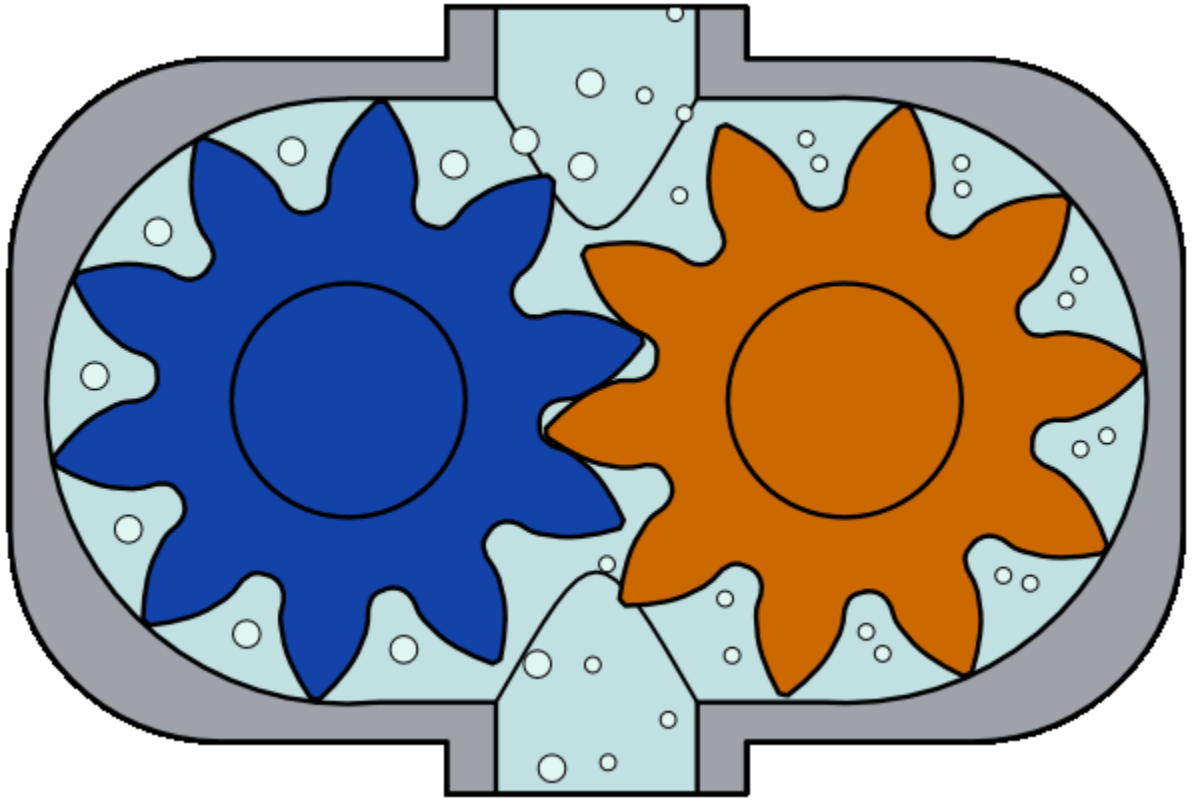
Lobe Pump



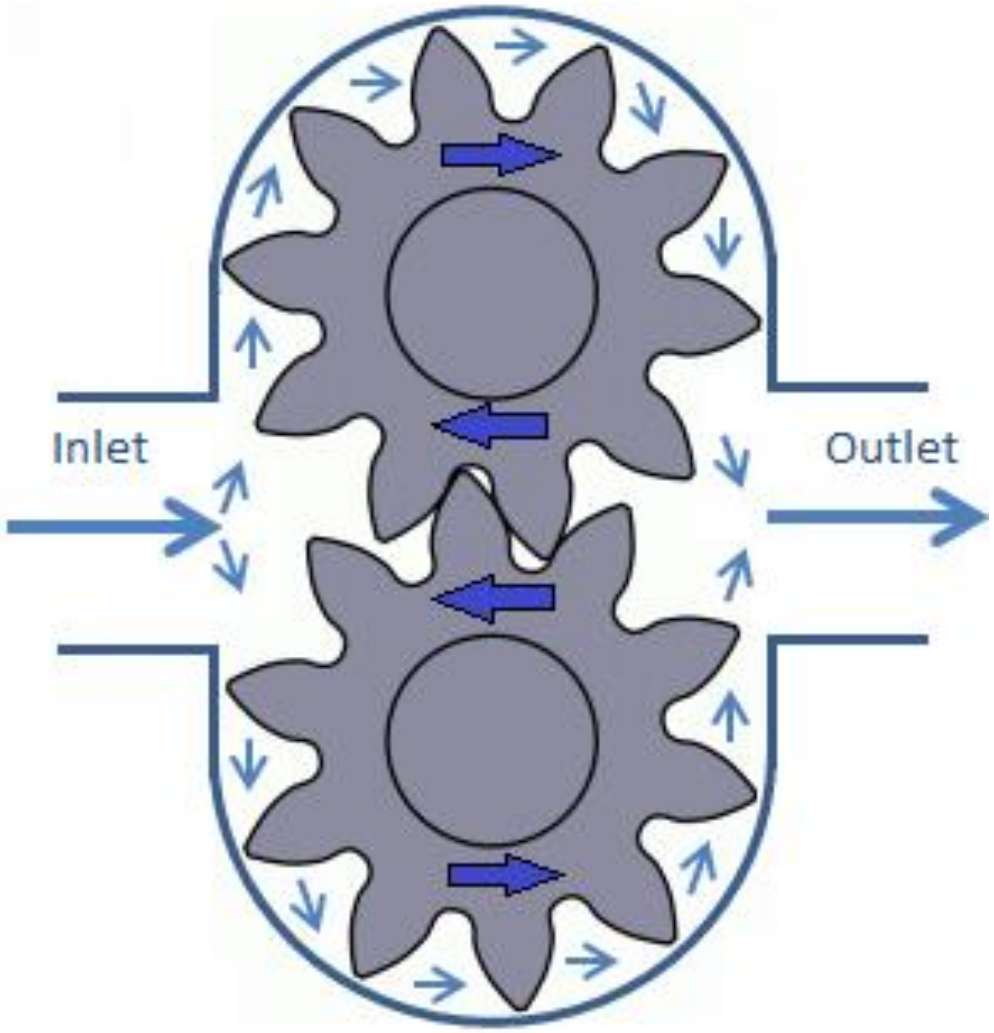
Source: https://gfycat.com/decimalsoftcanvasback

Source: https://www.youtube.com/watch?v=mEF3qh-hH-I

Gear Pump



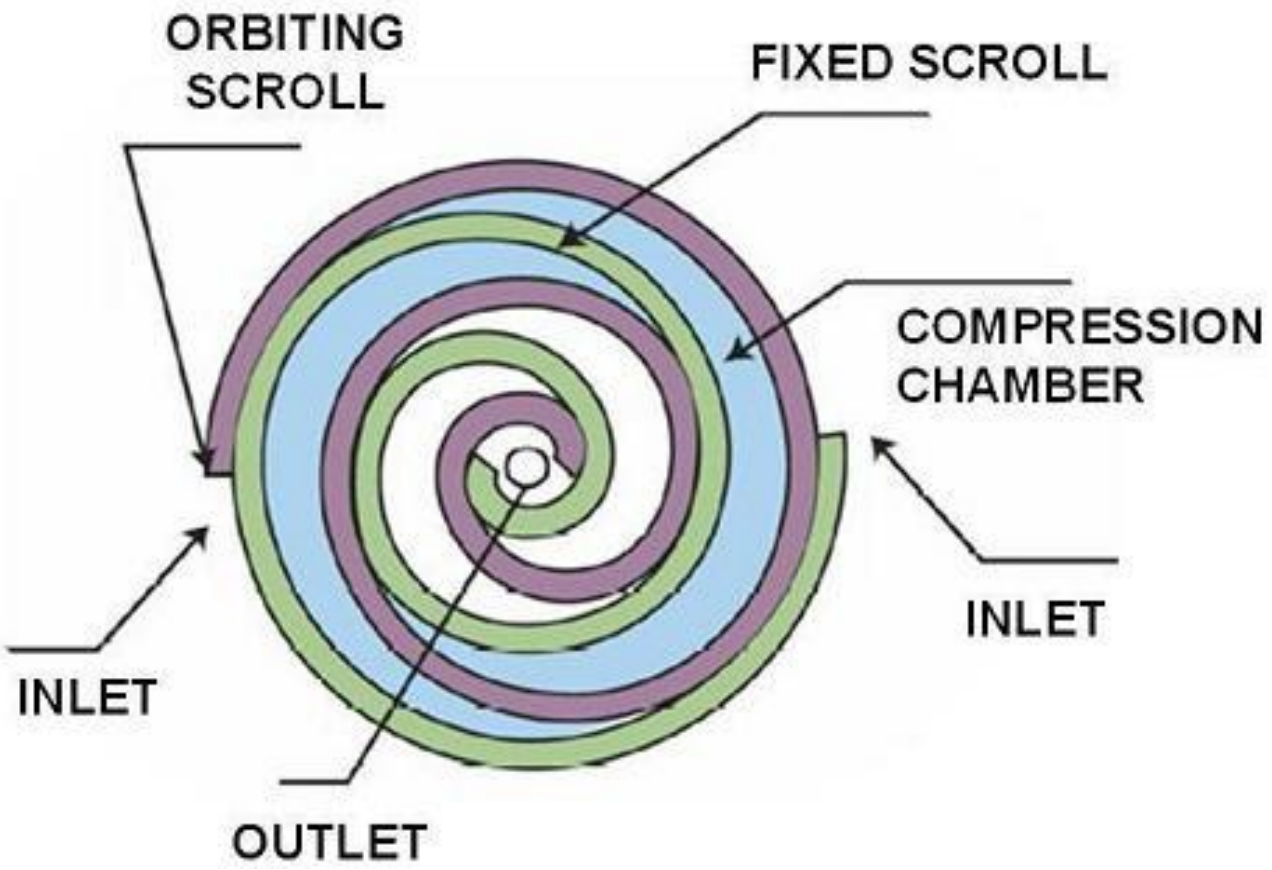
Source: http://bestanimations.com/Science/Gears/Gears4.html



Source: http://processprinciples.com/2012/07/gear-pumps/

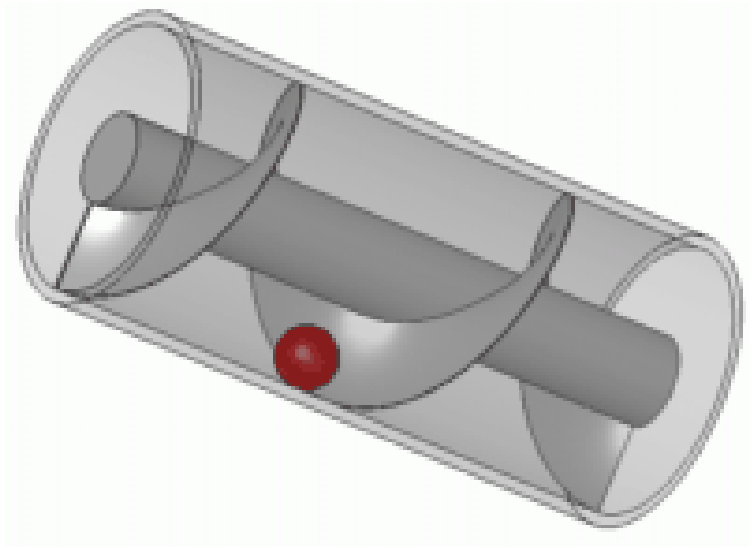
Scroll Pump

Source: https://gfycat.com/discover/compresor-gifs

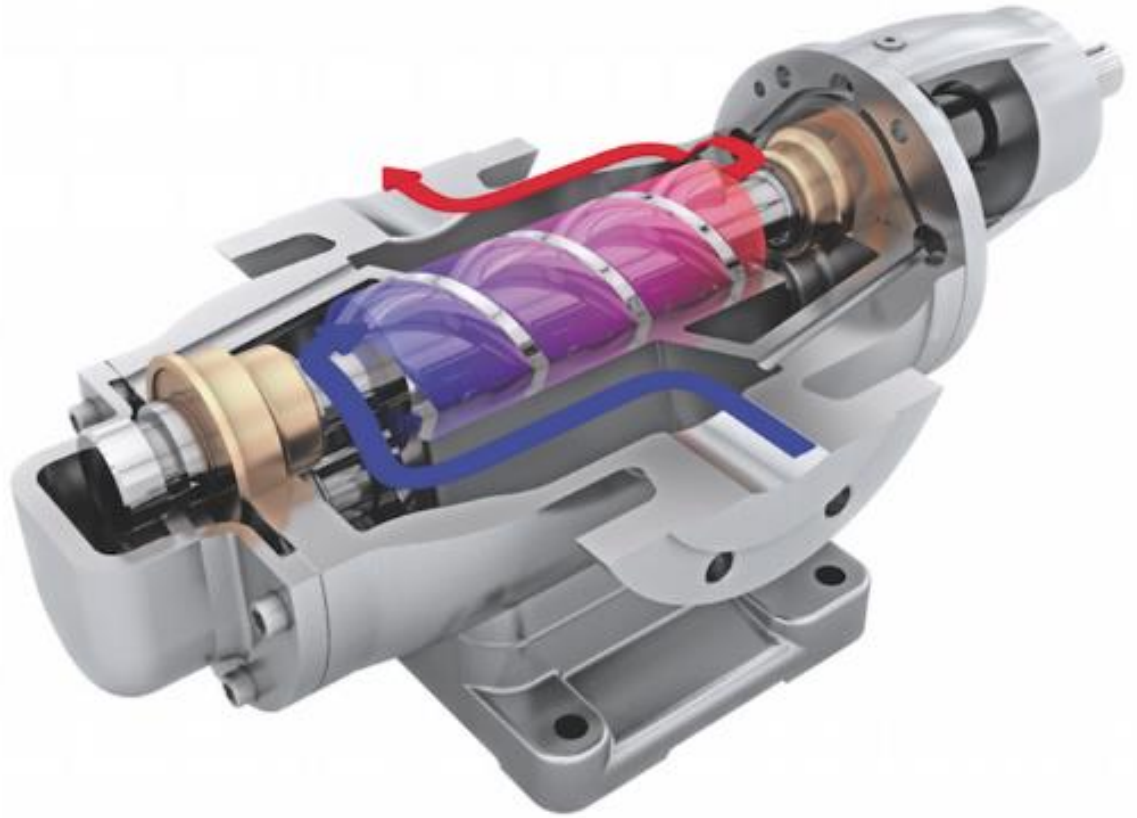


Source: http://www.gentecsys.com/Knowledge/KB04_comp_tech.htm

Screw Pump or Cavity pump

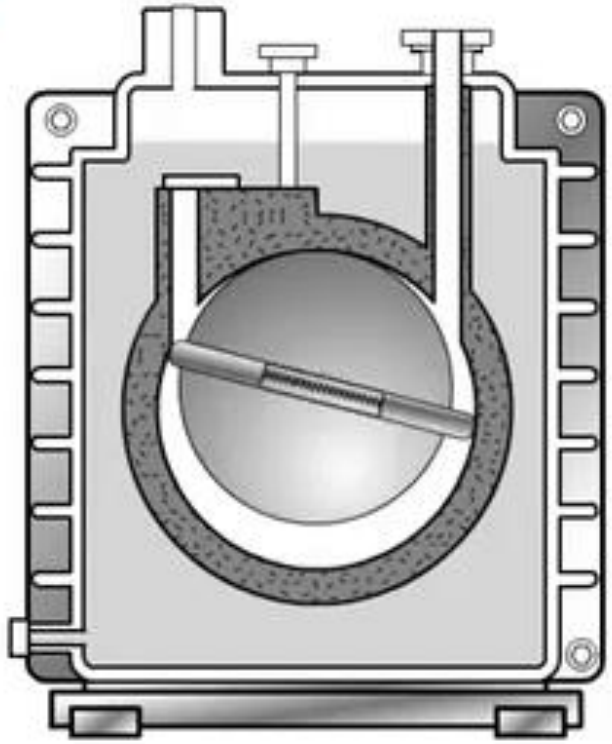


Source: https://en.wikipedia.org/wiki/Archimedes%27_screw

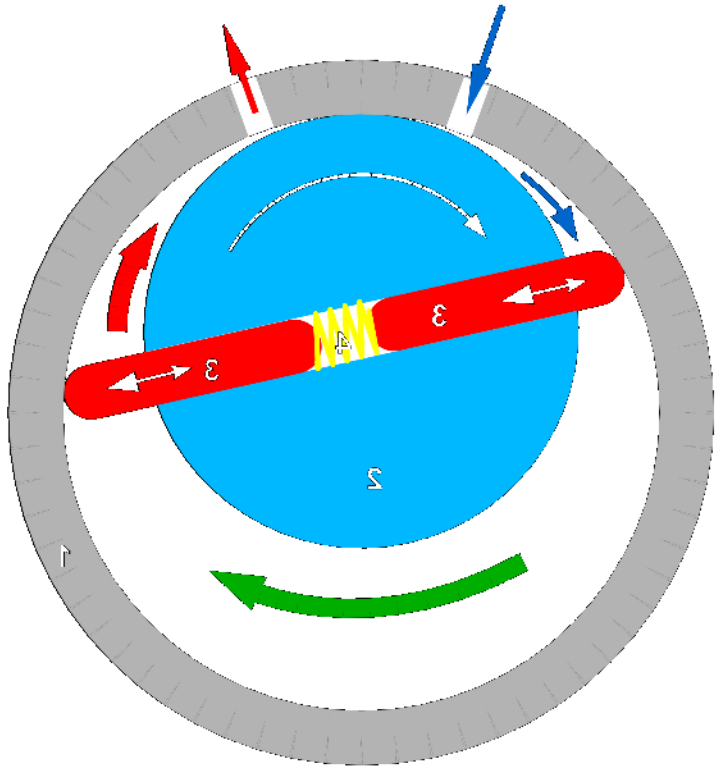


Source: https://empoweringpumps.com/leistritz-screw-pump-applications-in-pipelines-refineries-and-chemical-plants/

Vane pump



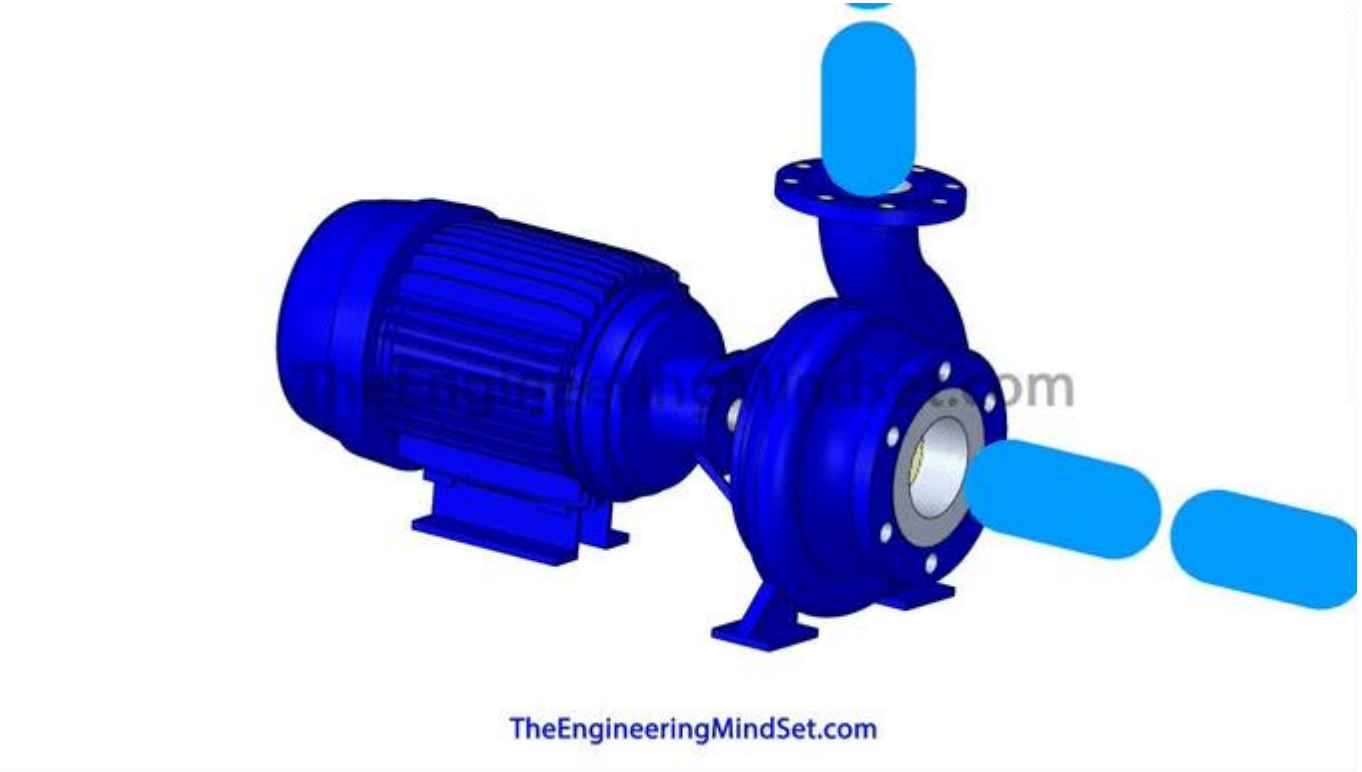
Source: https://makeagif.com/gif/rotary-vane-pump-animation-FwVfPQ

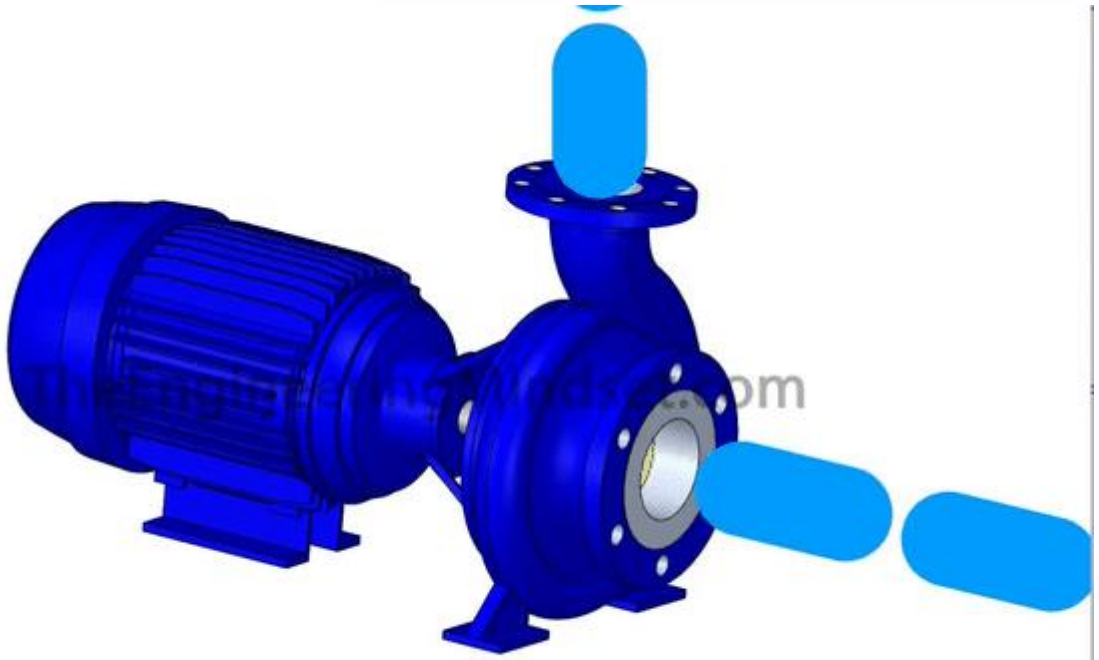


Source: https://en.wikipedia.org/wiki/Rotary_vane_pump

Dynamic machines:

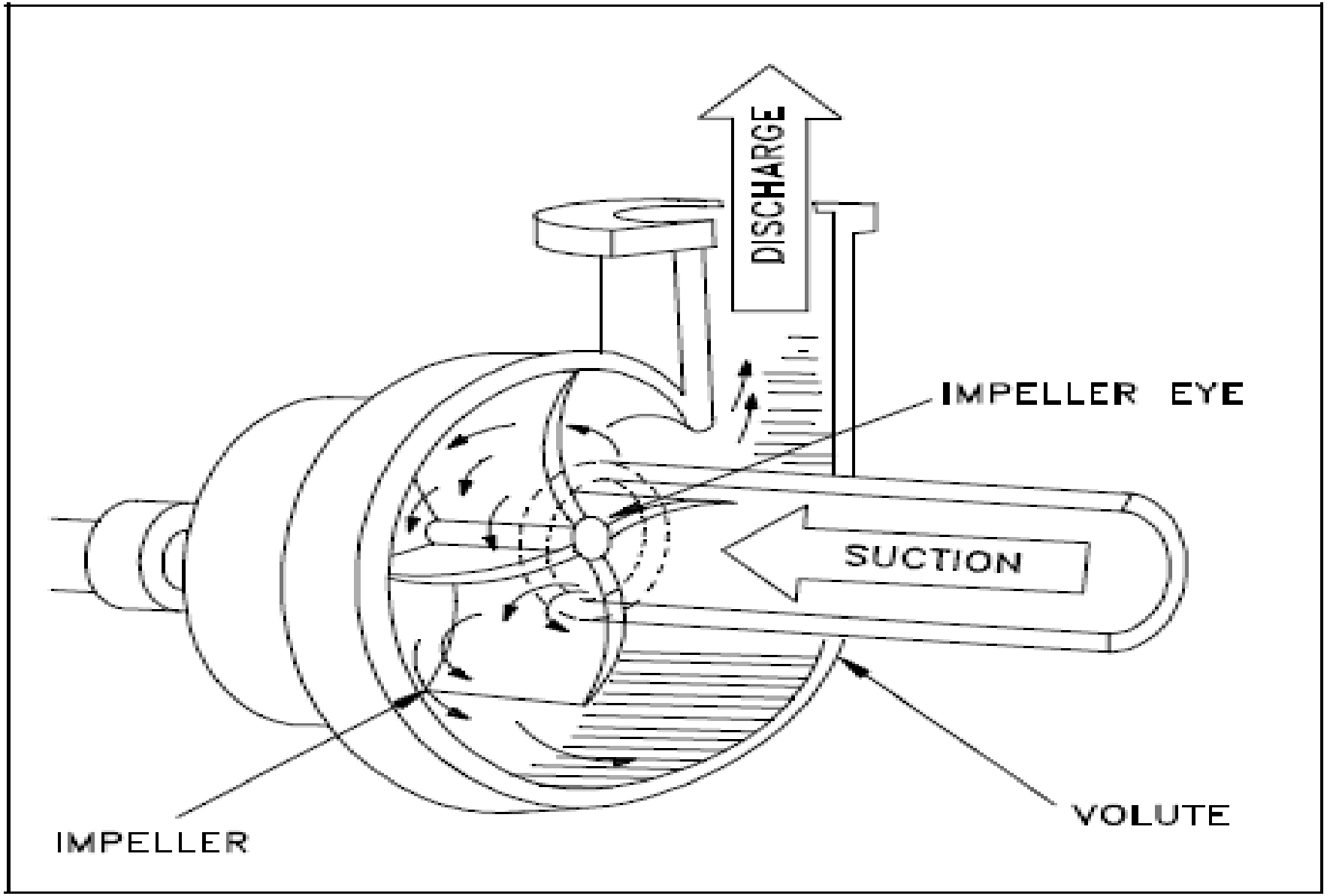
Centrifugal pump



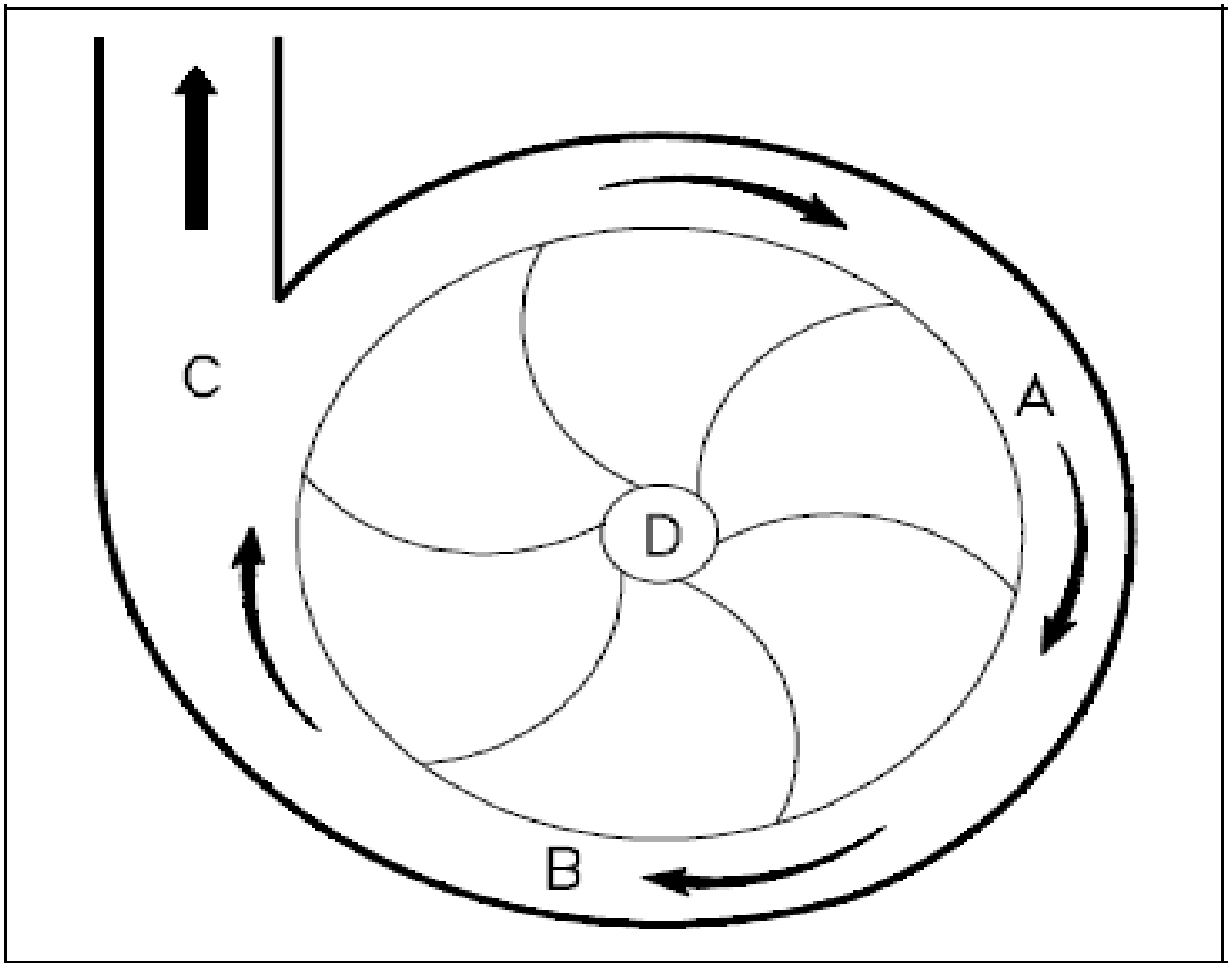


Source: https://gfycat.com/fataleducatedcolt

CENTRIFUGAL PUMP



CENTRIFUGAL COMPRESSOR



Thank You