Thermodynamics ENME 333
Chapter 1
Introduction

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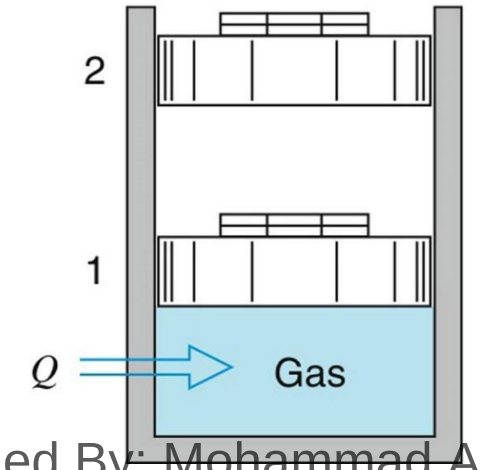
Outline

- Definition
- Laws of thermodynamics
- Practical examples
  - Steam power plant
  - Refrigeration cycle
  - Fuel cell
  - Gas turbine
  - Air separation plant

- Notes are based on 6th ed. of text book.

What is thermodynamics?

- **Thermodynamics**: is the science that deals with energy transformation including work and heat, and the physical properties of substances involved in these transformation.
- A simple engineering system may include a gas contained in a cylinder fitted with a piston, the gas may expand as a result of heating. One might analyze the system with respect to the heat supplied and cause the expansion, or might find the work done during the expansion process. One can check if such changes are possible!

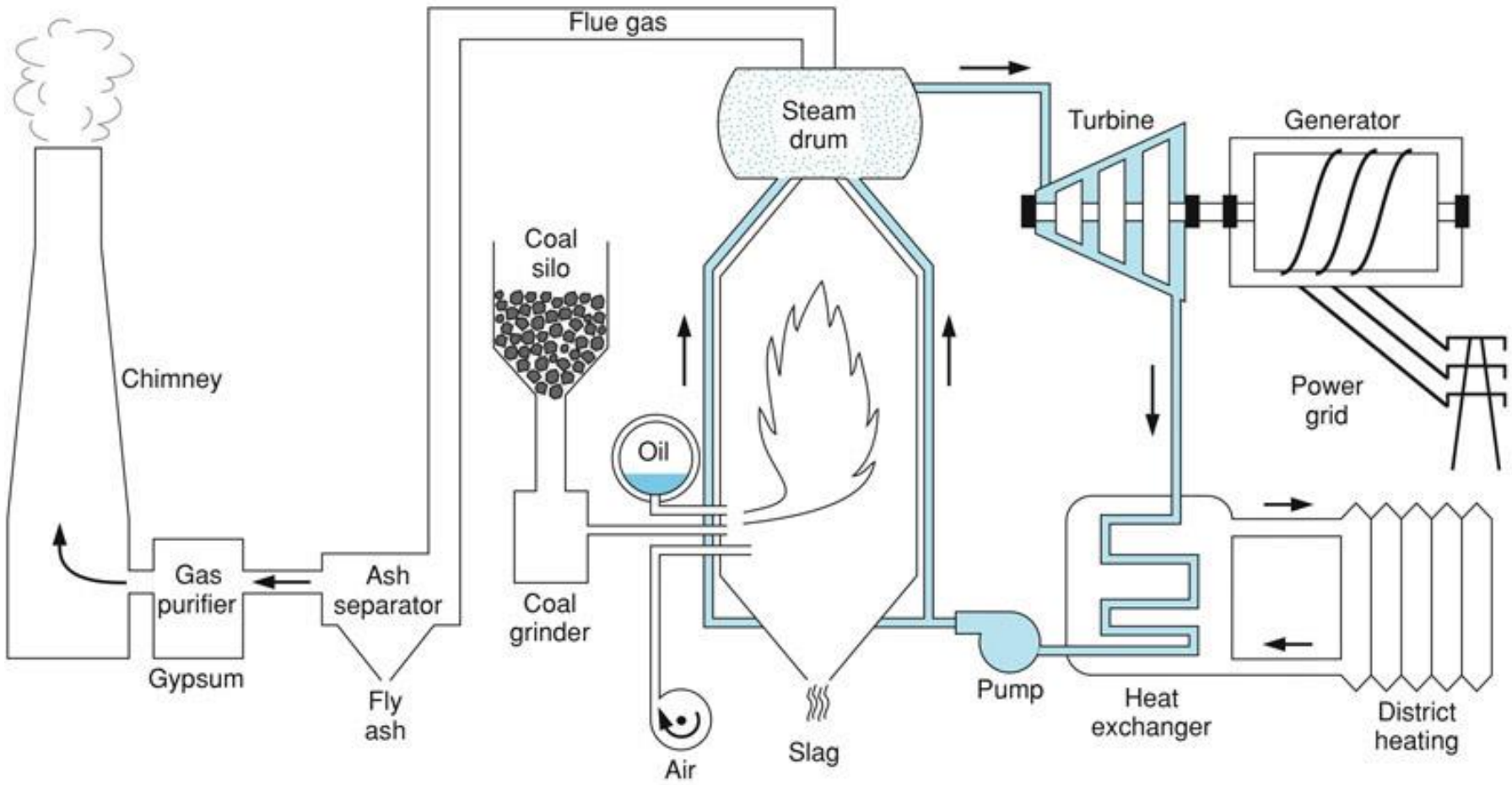


Laws of thermodynamics

- **Laws of thermodynamics**: are based on practical and experimental evidence, such laws include,
  - Zeroth law of thermodynamics, related to temperature measurements.
  - First law of thermodynamics, energy conservation.
  - Second law of thermodynamics, indicates the direction of change in systems.
  - Third law of thermodynamics, related to absolute temperature scale.
- Above laws will be studied in this course and applied to engineering problems.

Simple steam power plant

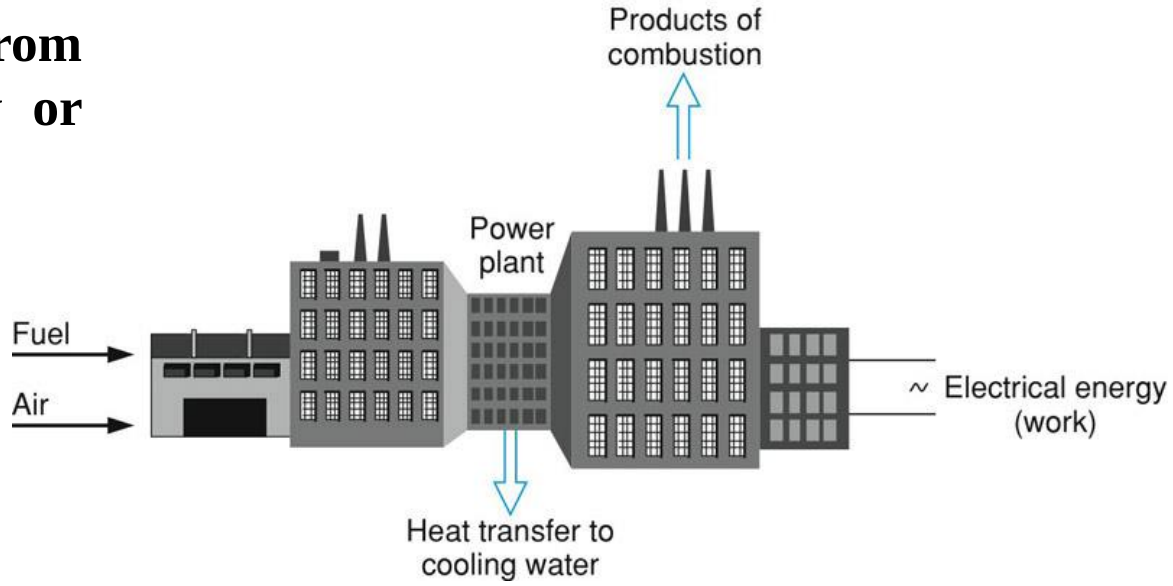
- In the steam power plant thermal energy, usually from combustion of some fossil fuel is converted in to shaft work from which electricity can be generated by means of electrical generator.
- The steam power plant works in a thermodynamic cycle, a schematic of the plant is given in figure 1.1 p. 2 , the cycle contains the following devices or components.
- Steam generator: where high pressure liquid is converted into steam, by means of a heat source.
- Steam turbine: as steam expands in the turbine shaft work is produced.
- Condenser: the steam leaving the turbine at low pressure condenses to liquid by cooling in the condenser.
- Pump: the low- pressure liquid is brought to higher pressure by the pump. The pump requires work to accomplish its task.



Power plant - energy

From energy point of view heat is added to the cycle in the steam generator, and removed from the cycle in the condenser.
Work is produced by the turbine and work is required by the pump.
The net work is that produced by turbine minus that used by the pump. This net work is used to drive the electric generator.

The heat source for the cycle could be from combustion of some fossil fuel, or solar energy or nuclear energy.



Thermal efficiency

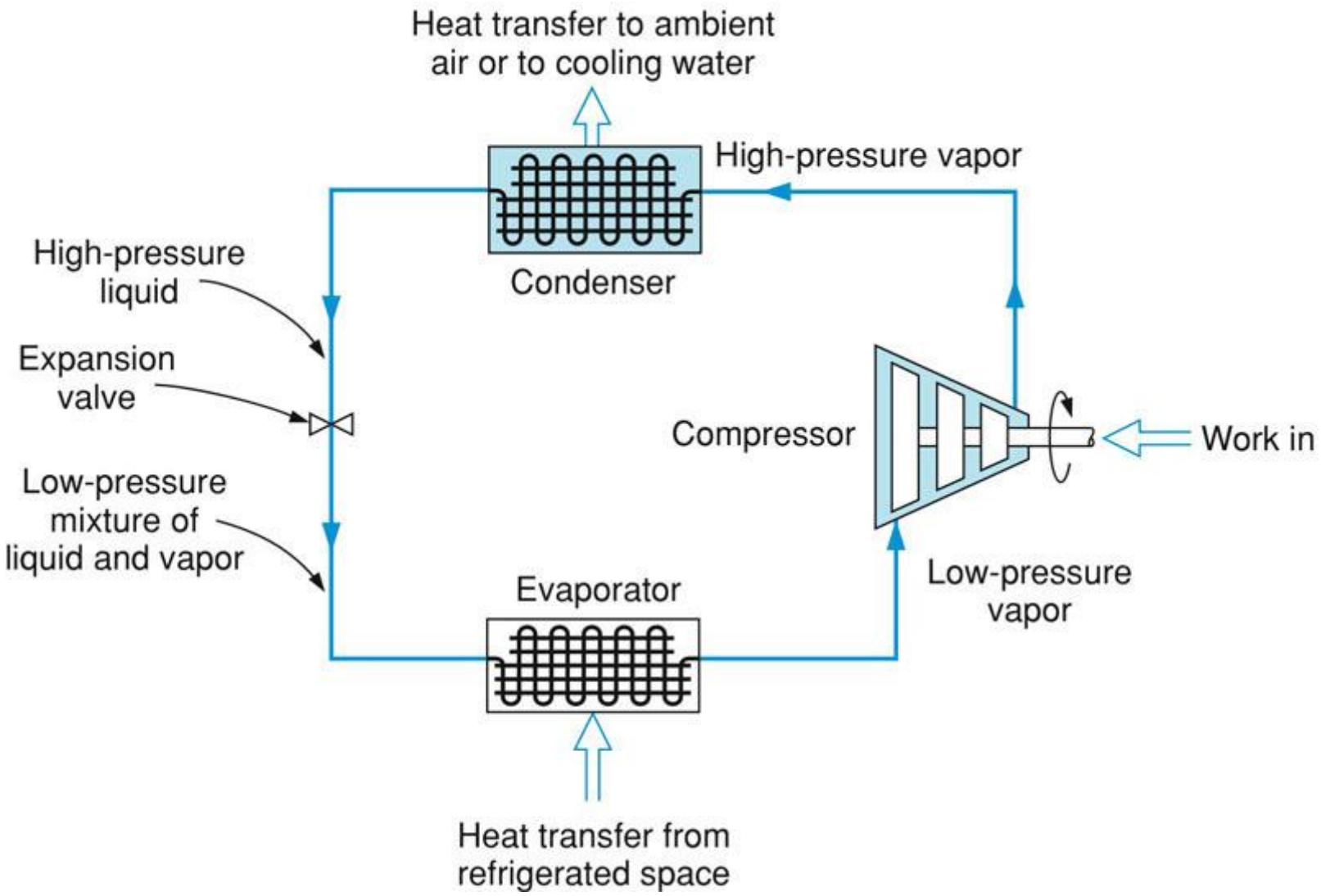
- Thermal efficiency of the power plant is defined as the output, the net work divided by the input, the heat added to the steam generator.

Vapor compression refrigeration cycle

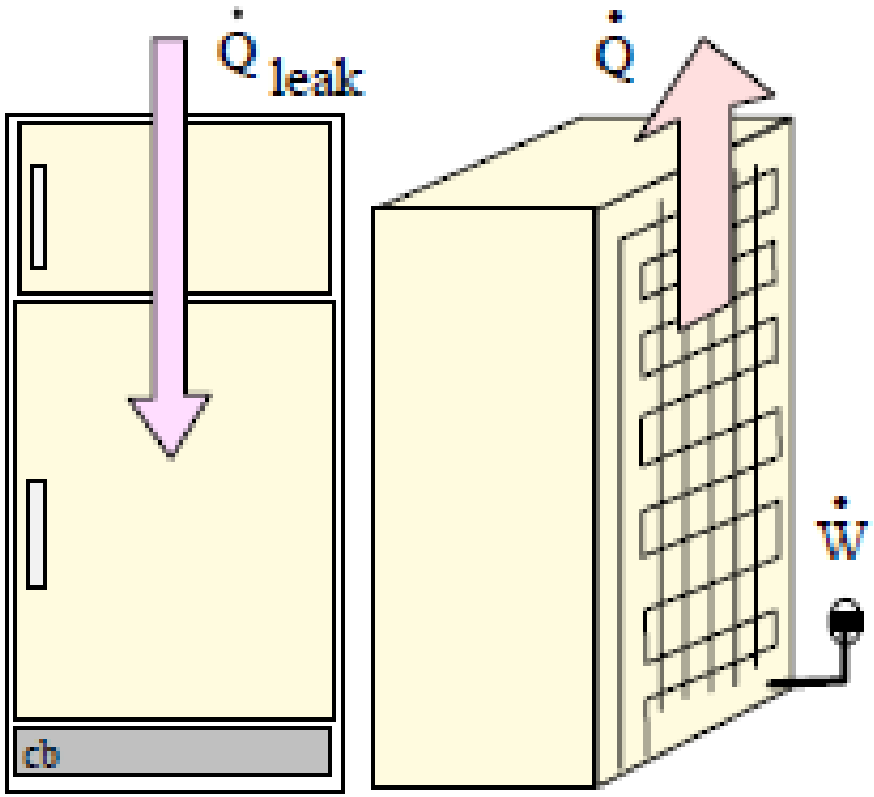
- A schematic of the vapor compression refrigeration cycle is shown in figure 1.7 p.8 .
- The overall objective of the cycle is to transfer heat from a low temperature body to another body at higher temperature.
- This objective will result in the cooling of the body at the low temperature, which is the case in the refrigerator.

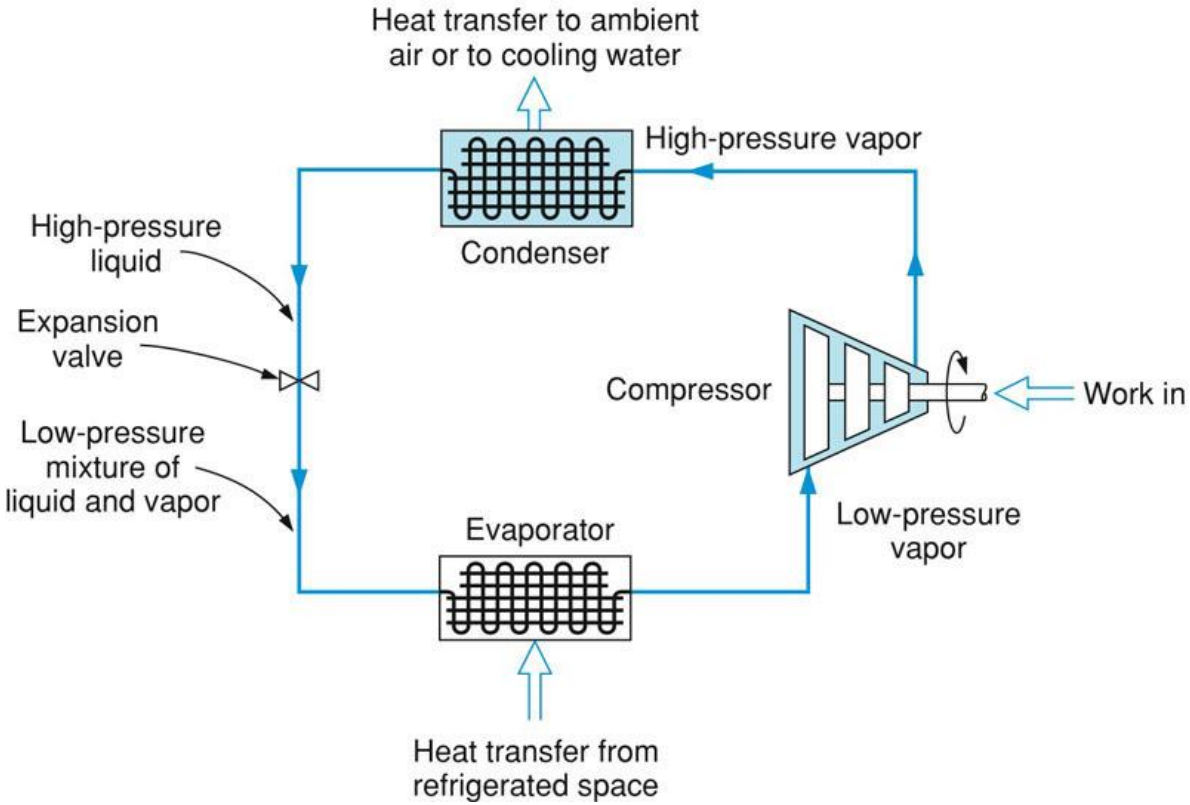
Vapor compression refrigeration cycle

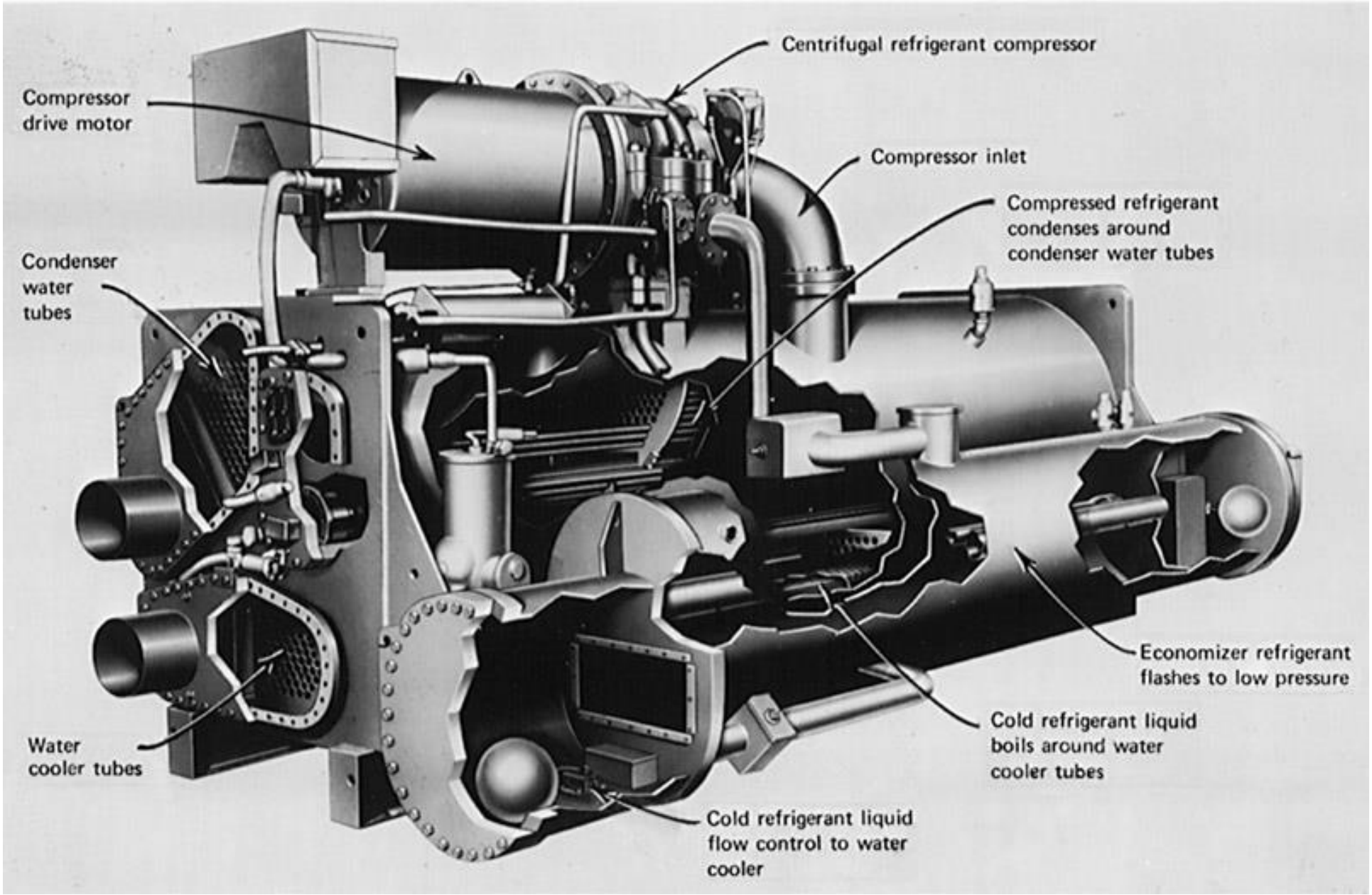
- The cycle consists of the following components:
  - Compressor which raises the pressure of the vapor from low pressure to a higher pressure and thus requiring work input.
  - Condenser which converts the vapor to liquid by cooling such vapor
  - expansion valve through which pressure will drop to lower pressure, partial vaporization will result after the valve
  - Evaporator through which the liquid to change to vapor by taking heat from its environment thus resulting in cooling of such environment.
- Compare this refrigeration cycle with the home refrigerator, and notice the location of each component of the cycle in the home refrigerator.



What do you think about using the heat rejected from the condenser for space heating?





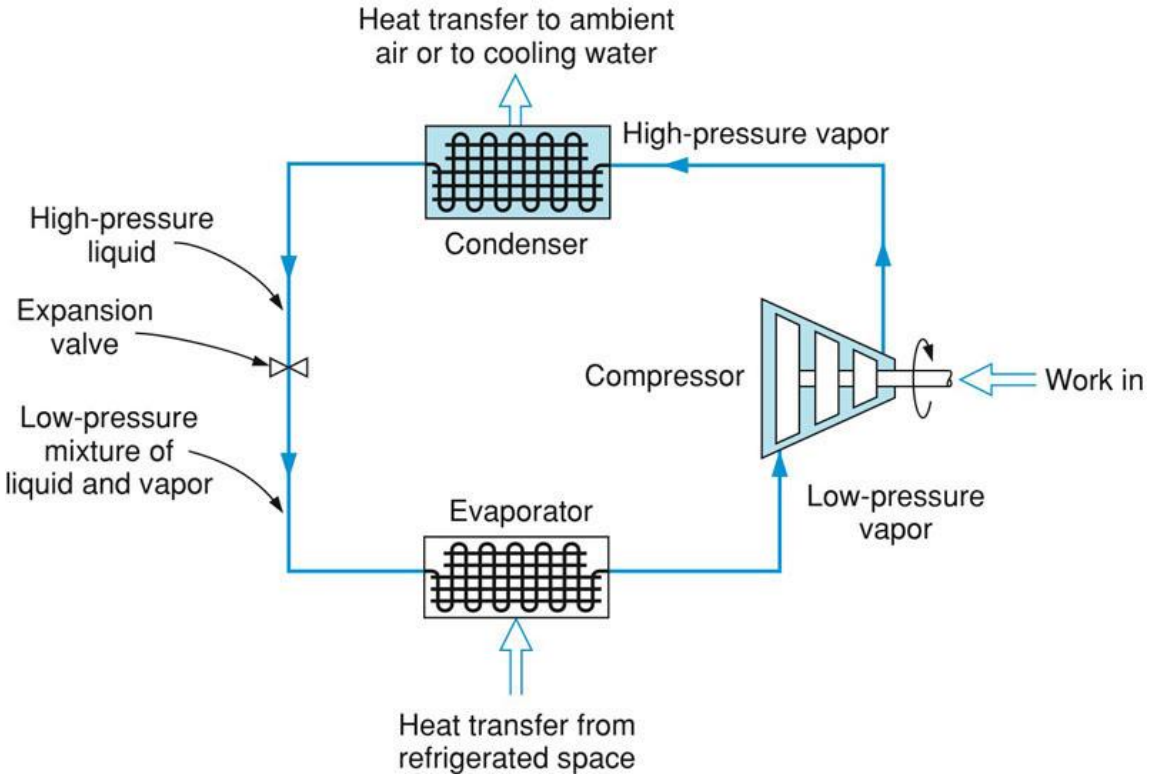


Working fluid

- The working fluid which circulates in this cycle is some type of refrigerant, examples of refrigerants include ammonia, Freon.
- Such material should be nontoxic and environment friendly

Efficiency of cycle

- The efficiency for such cycle is termed as the coefficient of performance
- and is defined as the required output divided by the cycle energy input, write down such coefficient of performance for the refrigerator.



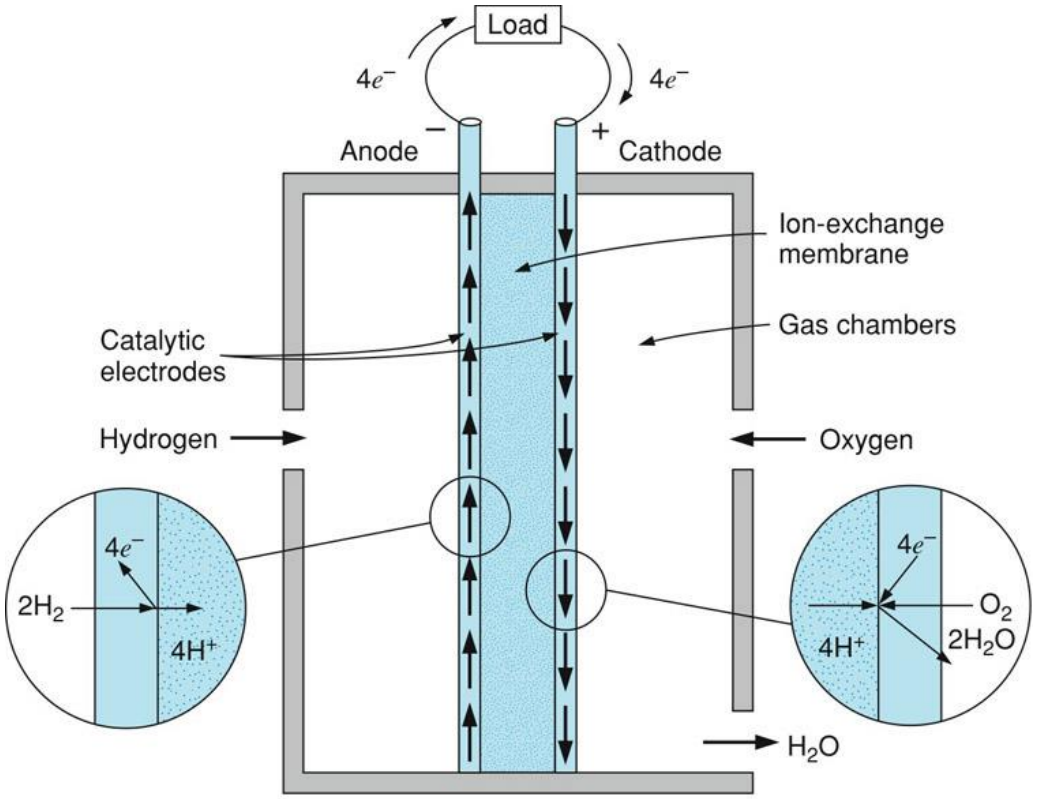
Fuel cell

The basic principle of operation is the creation of two chemical reactions; one reaction releases electrons that travel through an external circuit and return to be absorbed in the second chemical reaction.

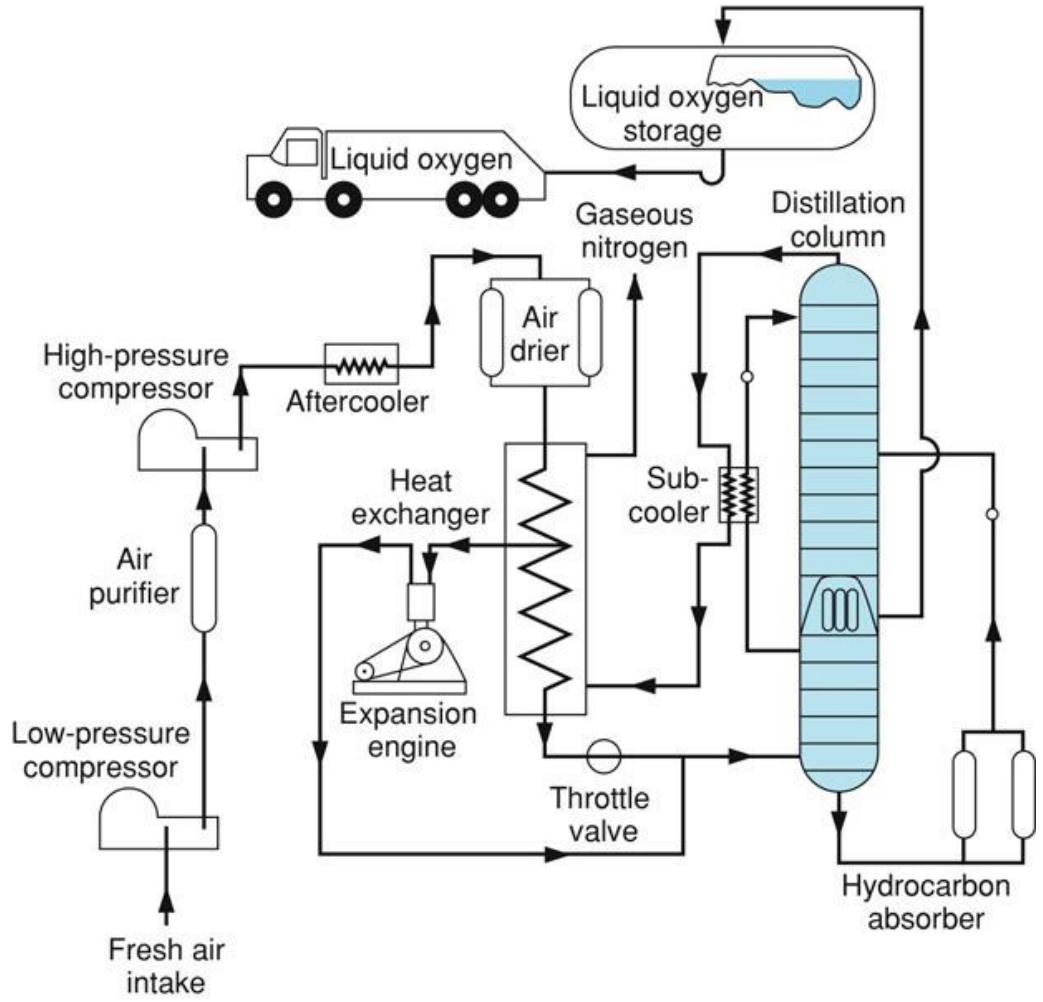
The two reactions occur on two electrodes, which are separated by a liquid or solid electrolyte through which ions will travel.

Anode reaction $2H_2 \longrightarrow 4e^- + 4H^+$

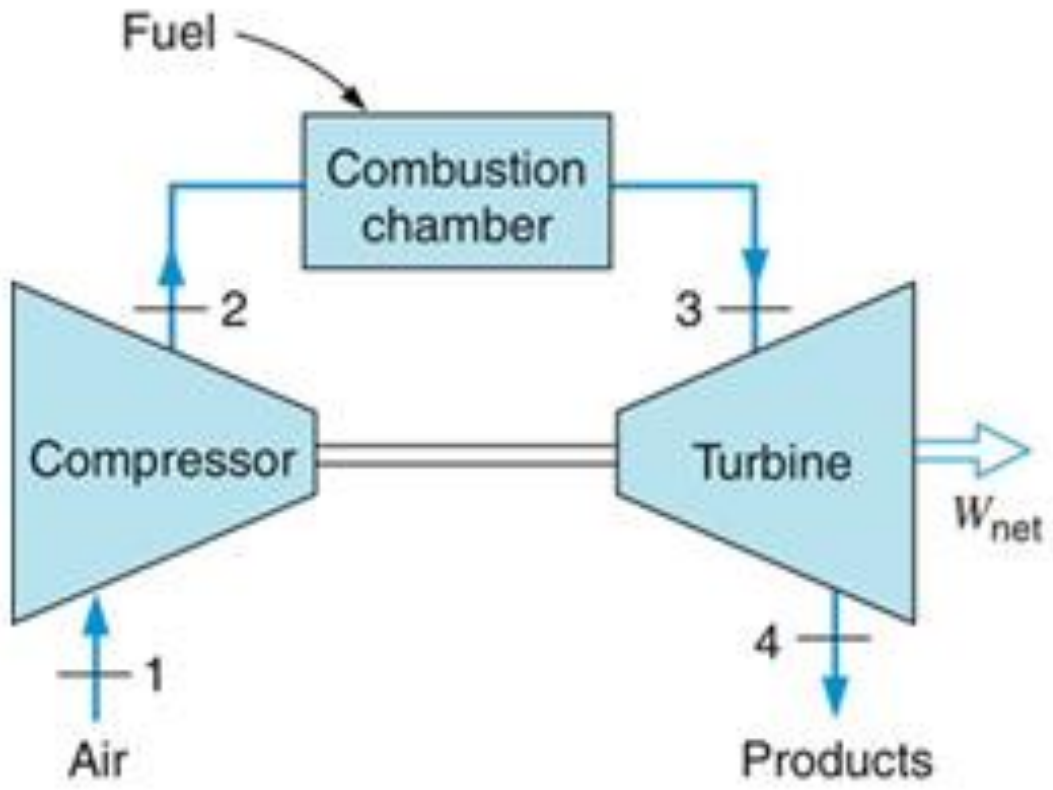
Cathode reaction $4H^+ + 4e^- + O_2 \longrightarrow 2\,H_2O$



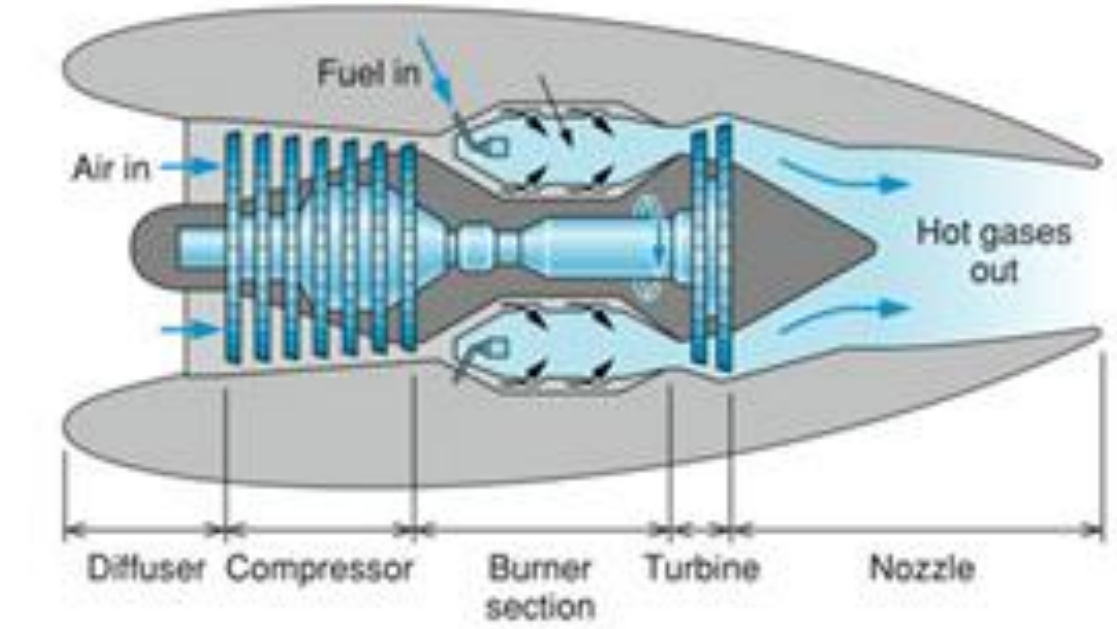
Air separation plant

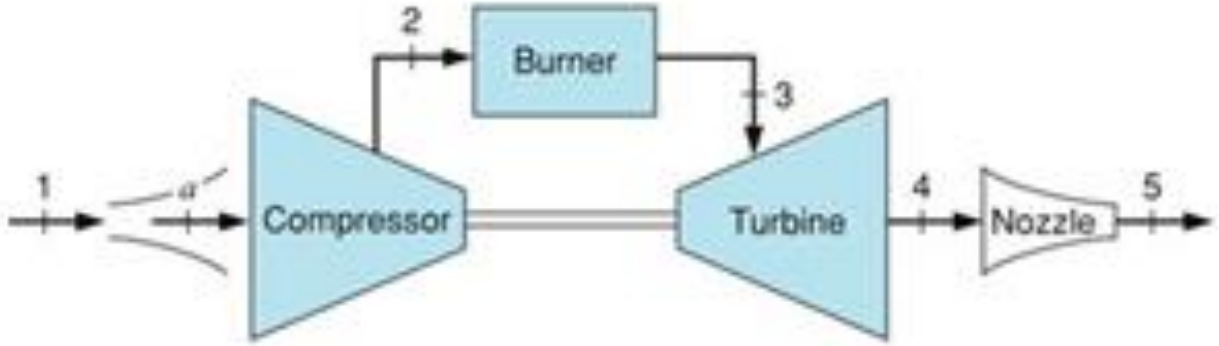


Gas turbine



Gas turbine and jet engine





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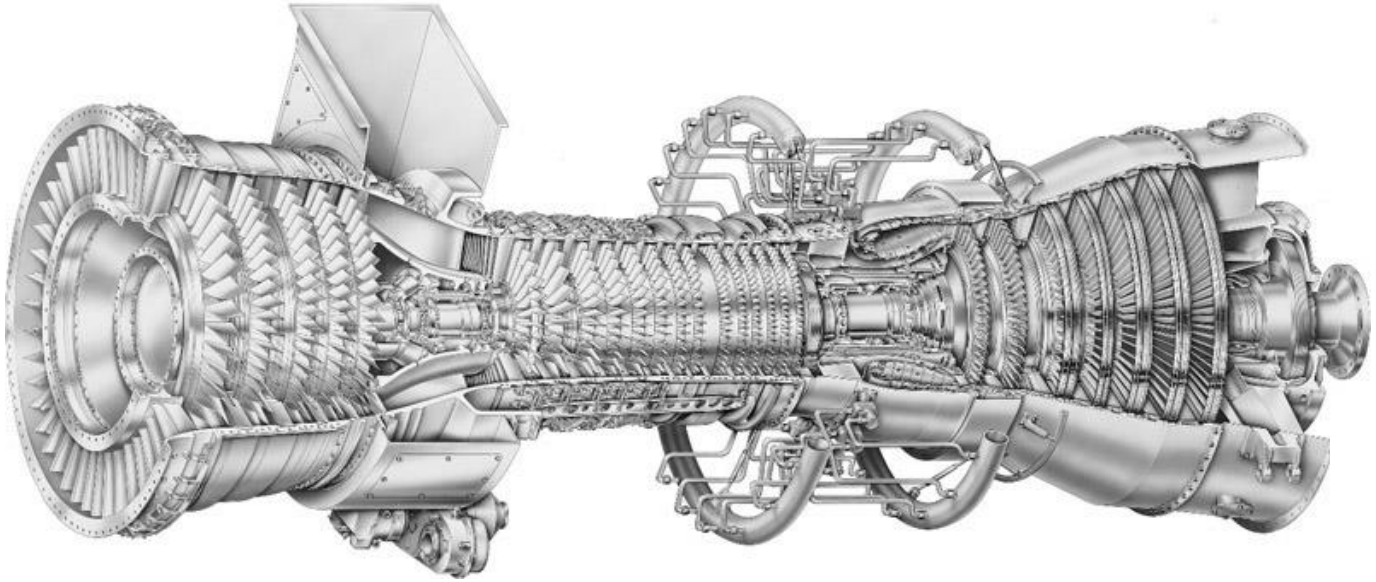

jet engine