3.5 Refrigeration Cycle

Refrigerators and air-conditioners are employed to cool the confined spaces they have (refrigerators) and are installed in (air conditioners) and they work basically in the same way. Air conditioners and refrigerators, use working fluids (refrigerants) that easily transform from liquid to gaseous state and vice versa. The heat transfer process takes place through this transformation process which results in cooling effect.

Refrigerators and air-conditioners have four main parts, the compressor, condenser, throttle valve (expansion valve) and the evaporator. The compressor and condenser are in most cases located outside the cooling system while the expansion valve and the evaporator is located inside the system or within the space to be cooled.

The refrigerant arrives at the compressor where it is compressed at high temperature and pressure. At the end of this process, the compressed working fluid moves to the condenser where the accumulated heat is rejected/expelled/dissipated to the surrounding. Thereafter, the cooled fluid passes through a throttling valve or expansion valve where the working fluid pressure is reduced and while the enthalpy remains constant and finally, when the working fluid gets to the evaporator, it extracts heat from the body in the cooling space for a refrigerator and extracts heat from the air forced over the evaporator in the case of an air conditioner, by vaporizing in the evaporator. It leaves the evaporator and the cycle is repeated.

An air conditioning system, has a fan in its unit, which circulates are inside the house. The cooling of the space or house takes place by forcing the circulating air over the evaporator. Hot air has a lower density compared to a cooler one and this makes it rise while the cooler air remains below. In the air conditioner, a vent exist where hot air is sucked in through, and forced out over the evaporator where the heat in the air is extracted before it is reintroduced to the house or space to be cooled. This cycle continues, until the set room temperature is reached, the thermostat senses this and turns of the air conditioner.

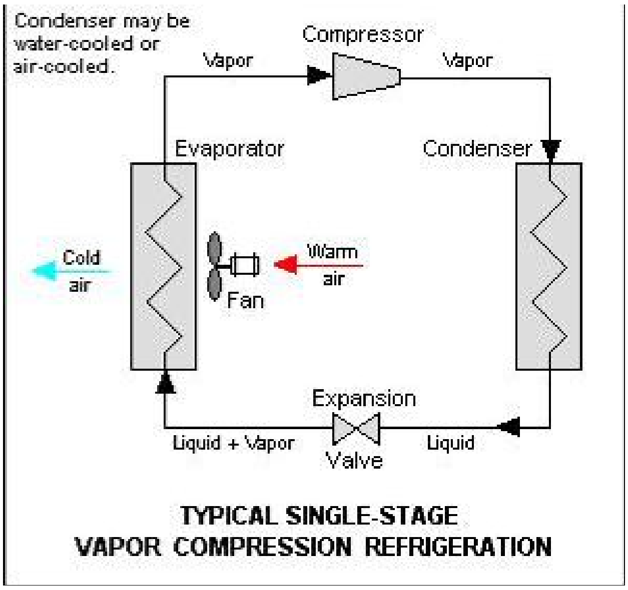

Figure 4: A refrigeration/Air conditoning cycle setup

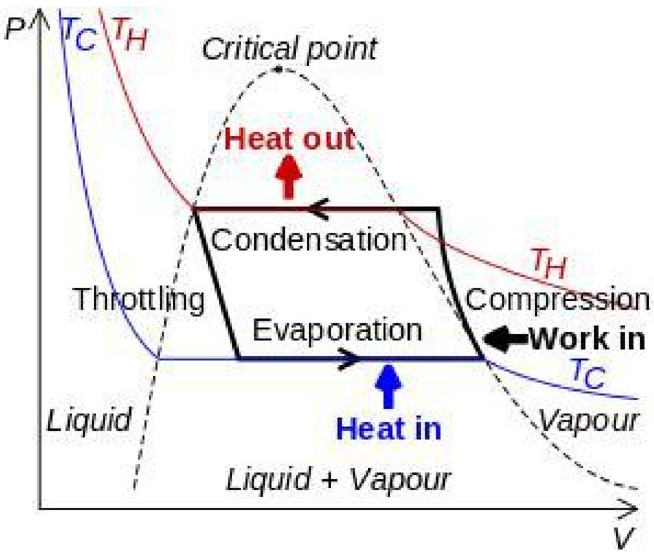

Figure 5: P-V diagram for a refrigeration cycle

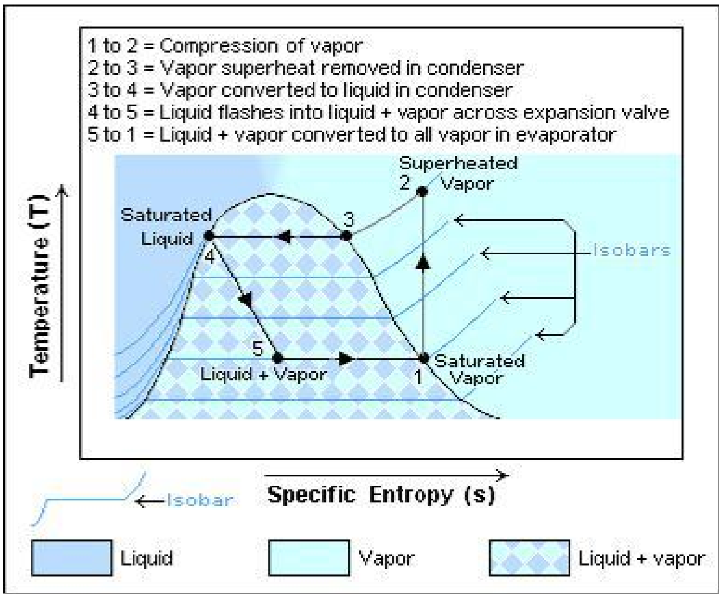

Figure 6: T-S diagram for a refrigeration cycle

Practice Questions

[1]. A reversed Carnot cycle is used for refrigeration and rejects 1000kW of heat at 67 ˚C while receiving heat at 250K. Show this on a T-S diagram and determine the COP and the power required.

[2]. A Carnot cycle heat engine receives 500kJ from a reservoir at 500 ˚C and rejects heat at 25 ˚C.

a) Show the cycle on a T-S diagram considering the working fluid as the system.

b) Calculate the work and efficiency of the cycle.

c) Calculate the change in entropy of the high temperature and low temperature reservoirs.

[3]. Carnot refrigeration cycle absorbs heat at 270 K and rejects heat at 300 K.

a) Calculate the coefficient of performance of this refrigeration cycle.

b) If the cycle is absorbing 1130 kJ/min at 270K, how many kJ of work is required per second.

c) If the Carnot heat pump operates between the same temperatures as the above refrigeration cycle, what is the coefficient of performance?