Homework 5

(Due on 22nd November, Tuesday)

2. Carbon dioxide enters an adiabatic nozzle at 800 K with a velocity of 50 m/s and leaves at 400 K. Assuming constant specific heats at room temperature, determine the Mach number (a) at the inlet and (b) at the exit of the nozzle. Assess the accuracy of the constant-specific-heat approximation.

(a)

$$V_{int} = 50m/s$$

$$c_{int} = \sqrt{kRT} = \sqrt{(1.288)(0.1889kj/kg \cdot K)(800K)(\frac{1000m^2/s^2}{1kj/kg})} = 442m/s$$

$$Ma_{int} = \frac{V_{int}}{c_{int}} = \frac{50m/s}{442} 0.113$$

(b)

$$V = \sqrt{2c_p(T_0 - T)}$$

$$= \sqrt{2 \times (0.846kJ/kg \cdot K)(800K - 400K)(\frac{1000m^2/s^2}{1kj/kg})} = 823m/s$$

$$c_{out} = \sqrt{kRT} = \sqrt{(1.289)(0.1889kj/kg \cdot K)(400K)(\frac{1000m^2/s^2}{1kj/kg})} = 312m/s$$

$$Ma_{out} = \frac{V_{out}}{c_{out}} = \frac{824m/s}{312} = 2.64$$

3. Why are throttling devices commonly used in refrigeration and air-conditioning applications?

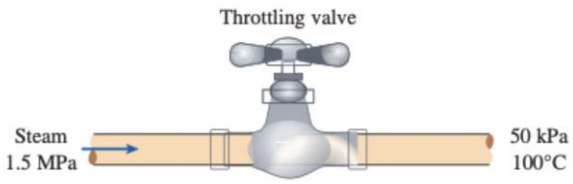
1. To bring down the pressure of the refrigerant

The high pressure of the refrigerant coming from the condenser require reduction to enable vaporization in the evaporator at the proper temperature. The throttling valve as a small aperture through which the refrigerant flows that lowers the pressure of the refrigerant to a point at which the refrigerant vaporize of which the refrigerant then passes into the evaporator in a partly as liquid and vapor at a low temperature and pressure.

2.To meet up with the load to be refrigerated (the amount of heat to be evacuated)

The throttling valve allows more refrigerant to flow through it when there is an increased load at a higher temperature to be refrigerated. Similarly, in a condition of reduced refrigeration load, hence, a lesser amount of heat to be evacuated, the throttling valve restricts the amount of flow of the refrigerant through it.

4. A saturated liquid–vapor mixture of water, called wet steam, in a steam line at 1500 kPa is throttled to 50 kPa and 100°C. What is the quality in the steam line?



Steam at outlet is a superheated steam, since T> T_{sat}(81.32℃).

From steam tables, the specific enthalpy is: $h_{out} = 2682.4kj/kg$

From steam tables, specific enthalpy at inlet is: $h_g = 2791kj/kg, h_f = 844.55kj/kg$,

The quality in the steam line is $\frac{2682.4kj/kg - 844.55kj/kg}{2791.0kj/kg - 244.55kj/kg} = 0.944$