FME 321: THERMODYNAMICS II

TUTORIAL SHEET III

RECIPROCATING COMPRESSORS

1. A single acting stage air compressor with 150mm bore and 200mm stroke takes in air at 1.0×10^5 N/m^2, 27°C and delivers it at 9.0×10^5 N/m^2. The compressor operates at 300rpm. Determine the mean effective pressure and the power required to drive the compressor when the compression process is:

   i. isothermal

   ii. adiabatic

   iii. polytropic (n=1.3)

   Neglect clearance volume

   (i) 2.2×10^5 N/m^2, 3.88 kW (ii) 3.08×10^5 N/m^2, 5.41kW,(iii) 2.9×10^5 N/m^2, 5.12 kW]

2. A two stage air compressor is used to compress 5 m^3/min air from 1.0×10^5 N/m^2, 27°C to 7.5×10^5 N/m^2.

   i. What will be the pressure in the intercooler?

   ii. If n=1.3, compare the minimum power required for compressing in two stages with that for a single stage compression.

   Assume no clearance and perfect intercooling.

   [(i) 2.74×10^5 N/m^2 ; (ii) 18.68kW; 20.74kW]

3. A reciprocating compressor is to deliver 20kg/min of air at 16×10^5 N/M^2. It receives atmospheric air at 20°C.

   i. Calculate the required power if the compressor is assumed to be 90% efficient.

   No cooling is assumed.

   ii. If it is decided that because T_2 is too high, two stages with an intercooler are necessary. Determine the power requirement for the proposed two stage adiabatic compressor.

   Assume 90% efficiency for each stage.

   [(i) 131.9 kW; (ii) 105 Kw]

4. Air is compressed steadily by a reversible compressor from an inlet state of 1.0×10^5 N/M^2 and 300 K to an exit pressure of 9.0×10^5 N/M^2.

   Determine the compressor work per unit mass for:-

   i. isentropic compression with k = 1.4

   ii. polytropic compression with n = 1.3

   iii. isothermal compression

   iv. ideal two stage compression with intercooling with a polytropic exponent of 1.3.

   [(i)263.2 kJ/kg,(ii)246.4 kJ/kg,(iii)189.2 kJ/kg,(iv)215.3 kJ/kg]

5. Air is compressed by adiabatic compressor from 1.0×10^5 N/m^2 and 12°C to a pressure of 8.0×10^5 N/m^{2}at a steady rate of 0.2 kg/s.

   If the isentropic efficiency of the compressor is 80% determine:-

   i. the exit temperature of air

   ii. the required power input to the compressor

   [Answer: (i) 569.5 K; (ii) 58.0 kW]

6. A two stage air compressor with perfect intercooling draws in air at 1.0×10^5 N/m^2, 27°C and delivers it to a receiver at a pressure of 8.5×10^5 N/m^2. If the index of compression is n = 1.3 calculate:

   i. The minimum work required to drive the compressor

   ii. The heat rejected to the intercooler per kg if air delivered

   Assume no clearance and no pressure drop in the intercooler.

   [Answer: (i)209.86 N.m/kg,(ii)85.4 kJ/kg]