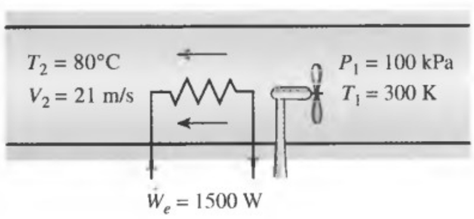
AS1300: Thermodynamics for Aerospace Engineers
Tutorial 3 (04/02/2020)

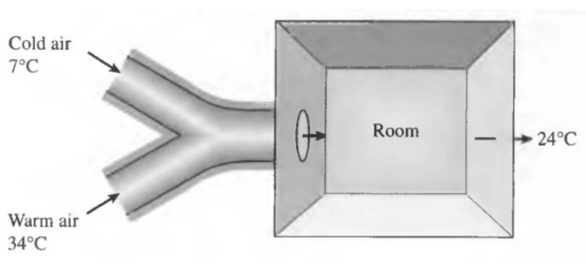
1. Nitrogen gas at 60 kPa and 7 ^oC enters an adiabatic diffuser steadily with a velocity of 275 m/s and leaves at 85 kPa and 27 ^oC. Determine (a) the exit velocity of the nitrogen and (b) the ratio of the inlet to exit area A_1/A_2 . Given: enthalpy of nitrogen at 280 K = 8141 kJ/kmol, enthalpy at 300 K = 8723 kJ/kmol.

2. An adiabatic air compressor compresses 10 L/s of air at 120 kPa and 20 ^oC to 1000 kPa and 300 ^oC. Determine (a) the work done by the compresser, in kJ.kg, and (b) the power required to drive the air compressor, in kW. Assume c_p of air as 1.018 kJ/kg/K, and gas constant of air as R_{air} = 0.287 kJ/kg/K.

3. Air at 300 K and 100 kPa steadily flows into a hair dryer having electrical work input of 1500 W. Because of the size of the air intake, the inlet velocity of the air is negligible. The air temperature and velocity at the air dryer exit are 80 ^oC and 21 m/s, respectively. The flow process is both constant pressure and adiabatic. Assume air has constant specific heats evaluated at 300 K.
(a) Determine the air mass flow rate into the hair dryer, in kg/s. (b) Determine the air volume flw rate at the hair dryer exit, in m^3/s. Assume c_p of air as 1.018 kJ/kg/K, and gas constant of air as R_{air} = 0.287 kJ/kg/K.



4. An air-conditioning system involves the mixing of cold air and warm outdoor air before the mixture is routed to the conditioned room in steady operation. Cold air enters the mixing chamber at 7 ^oC and 105 kPa at a rate of 0.75 m^3/s while warm air enters at 34 ^oC and 105 kPa. The air leaves the room at 24 ^oC. The ratio of the mass flow rates of the hot air to cold air is 2.2. Determine (a) the mixture temperature at the inlet of the room, and (b) the rate of heat gain of the room. Assume c_p of air as 1.018 kJ/kg/K, and gas constant of air as R_{air} = 0.287 kJ/kg/K.



5. A reciprocating air compressor takes in 2 m^3/min of air at 0.11 MPa and 20 ^oC and delivers it to an aftercooler at 1.5 Mpa and 111 ^oC. The air is then cooled at a constant pressure to 20 ^oC. The power absorbed by the compressor is 4.15 kPa. Determine the heat transfer in (a) compressor, and (b) cooler.

6. A turbocompressor delivers 2.33 m^3 *s* of air at 0.275 MPa, 43 °C which is then heated at this pressure to 430 °C and finally expanded in a turbine which delivers 1860 kW. During the expansion, there is a heat transfer of 0.09 MJ/s to the surroundings. Calculate the turbine exhaust temperature if changes in the kinetic and potential energy are negligible.

7. In a water cooling tower, air enters at a height of 1 m above the ground level and leaves at a height of 7 m. The inlet and outlet velocities are 20 km/s and 30 km/s repectively. Water enters at a height of 8 m and leaves at a height of 0.8 m. The velocity of water at the entry and exit are 3 m/s and 1 m/s respectively. Water temperatures are 80 °C and 50 °C at the entry and exit respectively. Air temperature is 30 °C and 70 °C at its entry and exit respectively. The cooling tower is well insulated and a fan of 2.25 kW drives the air through the cooler. Find the amount of air per second required for 1 kg/s of water flow. The c_p values for air and water are 1.005 and 4.187 kJ/kg/K respectively.

8. In an oil cooler, oil flows steadily through a bundle of metal tubes submerged in a steady stream of cooling water. Under steady flow conditions, oil enters at 90 °C and leaves at 30 °C, while water enters at 25 °C and leaves at 70 °C. Th enthalpy of oil at T °C is given by:

$$h = 1.68\,T + 10.5 \times 10^{-4}\,T^2 \text{ kJ/kg}$$

What is the cooling water flow required for cooling 2.78 kg/s of oil?