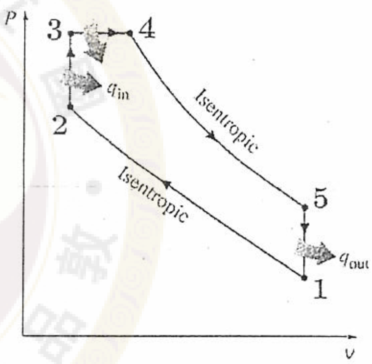
1. (20%) Steam at T_i = 320 °C flow in a cast iron pipe (k = 80 W/m-K) whose inner and outer diameters are D_i= 5 cm and D_o = 5.5 cm, respectively. The pipe is covered with 3-cm-thick glass wool insulation with k = 0.05 W/m-K. Heat is lost to the surroundings air at T_o = 5°C by natural convection with heat transfer coefficient of h_o = 18 W/m^2-K. Taking the heat transfer coefficient inside the pipe as h_i = 60 W/m^2-K, determine the heat loss rate from the steam per unit length of the pipe. Also determine the heat temperature drops across the pipe shell and the insulation. What is the critical radius of insulation for this case? If you increase the thickness of the insulation, will the heat loss rate be reduced? Why so?

2. (20%) Cold water enters inside the copper tube of diameter D_i at temperature T_i with mass flow rate m and specific heat Cp. It is heated by steam at constant temperature T_s on the outside surface of the tube. Determine the exit temperature of the cold water at exit if the total length of the tube is L. You may neglect the conduction resistance through the tube wall. The heat transfer coefficient of the condensing steam on the tube wall is h. Also determine the total heat transfer rate from the steam into the cold water.

3. (10%) Plot the figure for the variation of the blackbody emissive power $E_{b\lambda}$, W/m^2-μm with wavelength λ, μm for several temperatures (5800 K, 4000K 1000K, 300K, 100K). From that explain the green house effect and the global warming phenomenon.

4. (35%) A dual cycle is a combination of the Otto and Diesel cycles as shown in the figure. It consists of an isentropic compression process, a heat-addition process, an isentropic expansion process, and a constant-volume heat rejection process. The air is heated first at constant volume (state 2 to state 3) and then at constant pressure (state 3 to state 4). The dual cycle with air as the working fluid has a compression ratio of r (ratio of the maximum volume to the minimum volume) and a cutoff ratio of r_c (ratio of the volume at the end of the heat-addition process to the minimum volume). At the beginning of the compression process, the working fluid is at temperature T_1 and pressure P_1. The total heat transferred to air during the whole heat-addition process is q_{in} (kJ/kg). By assuming air is an ideal gas with constant properties (including the gas constant R, specific heat at constant volume c_v and specific heat at constant pressure c_p), determine (a) the temperatures at the end of each process and (b) the thermal efficiency of the dual cycle in terms of T_1, P_1, r, r_c, q_{in}, R, c_v, c_p and $k=c_p/c_v$.



5. (15%) Answer the following questions clearly but briefly.

(i) A system undergoes a process between two fixed states (state 1 and state 2) first in a reversible manner and then in an irreversible manner. For which case is the amount of the integral $\int_1^2 \delta Q/T$ greater? Why? (δQ is the inexact heat differential and T is the temperature.)

(ii) Somebody claims to have developed a new heat-engine cycle that is operating between the temperature limits of 300K and 800K and has a theoretical efficiency of 0.65. How do you evaluate this claim?

(iii) What is a so-called quasi-equilibrium process?

試題隨卷繳回