

※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. As Fig. 1, please draw a simple P - v diagram of a pure substance, including each region, line and point name. (20%)

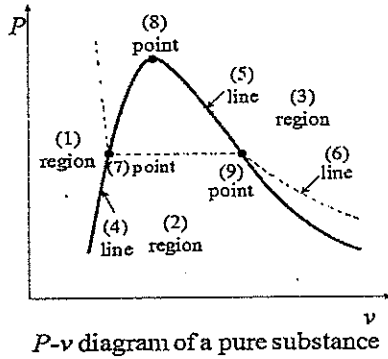


Fig. 1

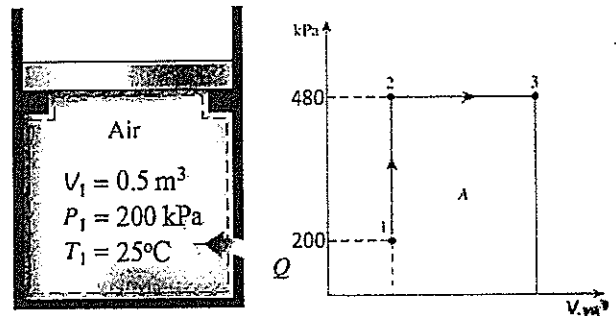


Fig. 2

2. As Fig. 2, a piston-cylinder device initially contains air at 200 kPa and 25°C. At this state, the piston is resting on a pair of stops, and the enclosed volume is 0.5 m³. The mass of the piston is such that a 480 kPa pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done (W_b) by the air, and (c) the total heat transferred to the air. (The property of air is $R = 0.287$ kJ/kg·K) (30%)
3. As Fig. 3, R-134a enters the condenser of a residential heat pump at 1 MPa as a saturated vapor at a rate of 0.1 kg/s and leaves at 1 MPa as a saturated liquid. If the compressor consumes 6 kW of power, determine (a) the COP of the heat pump and (b) the rate of heat absorption from the outside air. (25%)

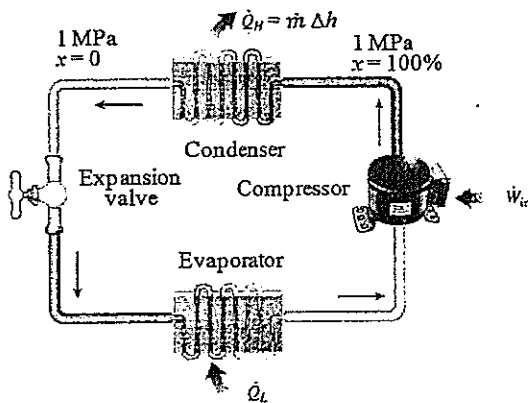


Fig. 3

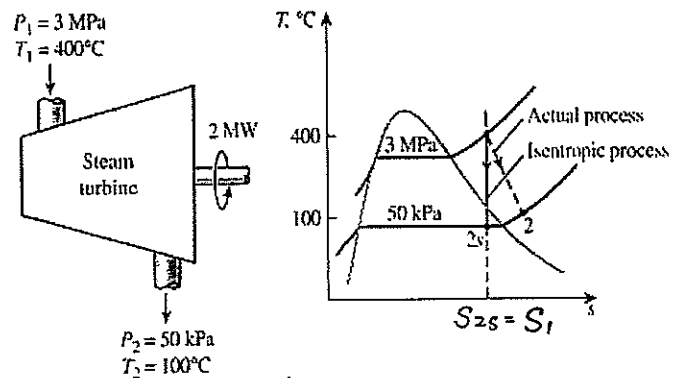


Fig. 4

4. As Fig. 4, steam enters an adiabatic turbine steadily at 3 MPa and 400 °C and leaves at 50 kPa and 100 °C. If the power output of the turbine is 2 MW, determine (a) the isentropic efficiency of the turbine and (b) mass flow rate of steam flowing through the turbine. (25%)

Tables

Table 1 Ideal-gas properties of air

| <i>T</i> K | <i>h</i> kJ/kg | <i>P_r</i> | <i>u</i> kJ/kg | <i>v_r</i> | <i>s^o</i> kJ/kg·K | <i>T</i> K | <i>h</i> kJ/kg | <i>P_r</i> | <i>u</i> kJ/kg | <i>v_r</i> | <i>s^o</i> kJ/kg·K |
|---------------|-------------------|----------------------|-------------------|----------------------|---------------------------------|---------------|-------------------|----------------------|-------------------|----------------------|---------------------------------|
| 250 | 250.05 | 0.7329 | 178.28 | 979.0 | 1.51917 | 1300 | 1395.97 | 330.9 | 1022.82 | 11.275 | 3.27345 |
| 260 | 260.09 | 0.8405 | 185.45 | 887.8 | 1.55848 | 1320 | 1419.76 | 352.5 | 1040.88 | 10.747 | 3.29160 |
| 270 | 270.11 | 0.9590 | 192.60 | 808.0 | 1.59634 | 1340 | 1443.60 | 375.3 | 1058.94 | 10.247 | 3.30959 |
| 280 | 280.13 | 1.0889 | 199.75 | 738.0 | 1.63279 | 1360 | 1467.49 | 399.1 | 1077.10 | 9.780 | 3.32724 |
| 285 | 285.14 | 1.1584 | 203.33 | 706.1 | 1.65055 | 1380 | 1491.44 | 424.2 | 1095.26 | 9.337 | 3.34474 |
| 290 | 290.16 | 1.2311 | 206.91 | 676.1 | 1.66802 | 1400 | 1515.42 | 450.5 | 1113.52 | 8.919 | 3.36200 |
| 295 | 295.17 | 1.3068 | 210.49 | 647.9 | 1.68515 | 1420 | 1539.44 | 478.0 | 1131.77 | 8.526 | 3.37901 |
| 298 | 298.18 | 1.3543 | 212.64 | 631.9 | 1.69528 | 1440 | 1563.51 | 506.9 | 1150.13 | 8.153 | 3.39586 |
| 300 | 300.19 | 1.3860 | 214.07 | 621.2 | 1.70203 | 1460 | 1587.63 | 537.1 | 1168.49 | 7.801 | 3.41247 |
| 305 | 305.22 | 1.4686 | 217.67 | 596.0 | 1.71865 | 1480 | 1611.79 | 568.8 | 1186.95 | 7.468 | 3.42892 |

Table 2 Saturated R-134a – Pressure table

| Press., <i>P</i> kPa | Sat. temp., <i>T_{sat}</i> °C | Specific volume, m ³ /kg | | Internal energy, kJ/kg | | | Enthalpy, kJ/kg | | | Entropy, kJ/kg·K | | |
|----------------------------|--|---|--|---|---------------------------------|--|---|---------------------------------|--|---|---------------------------------|--|
| | | Sat. liquid, <i>v_f</i> | Sat. vapor, <i>v_g</i> | Sat. liquid, <i>u_f</i> | Evap., <i>u_{fg}</i> | Sat. vapor, <i>u_g</i> | Sat. liquid, <i>h_f</i> | Evap., <i>h_{fg}</i> | Sat. vapor, <i>h_g</i> | Sat. liquid, <i>s_f</i> | Evap., <i>s_{fg}</i> | Sat. vapor, <i>s_g</i> |
| 900 | 35.51 | 0.0008580 | 0.022703 | 100.84 | 148.03 | 248.88 | 101.62 | 167.69 | 269.31 | 0.37383 | 0.54326 | 0.91709 |
| 950 | 37.48 | 0.0008640 | 0.021456 | 103.70 | 146.11 | 249.82 | 104.52 | 165.68 | 270.20 | 0.38307 | 0.53333 | 0.91641 |
| 1000 | 39.37 | 0.0008700 | 0.020329 | 106.47 | 144.24 | 250.71 | 107.34 | 163.70 | 271.04 | 0.39196 | 0.52378 | 0.91574 |
| 1200 | 46.29 | 0.0008935 | 0.016728 | 116.72 | 137.12 | 253.84 | 117.79 | 156.12 | 273.92 | 0.42449 | 0.48870 | 0.91320 |
| 1400 | 52.40 | 0.0009167 | 0.014119 | 125.96 | 130.44 | 256.40 | 127.25 | 148.92 | 276.17 | 0.45325 | 0.45742 | 0.91067 |
| 1600 | 57.88 | 0.0009400 | 0.012134 | 134.45 | 124.05 | 258.50 | 135.96 | 141.96 | 277.92 | 0.47921 | 0.42881 | 0.90802 |

Table 3 Saturated water – Pressure table

| Press., <i>P</i> kPa | Sat. temp., <i>T_{sat}</i> °C | Specific volume, m ³ /kg | | Internal energy, kJ/kg | | | Enthalpy, kJ/kg | | | Entropy, kJ/kg·K | | |
|----------------------------|--|---|--|---|---------------------------------|--|---|---------------------------------|--|---|---------------------------------|--|
| | | Sat. liquid, <i>v_f</i> | Sat. vapor, <i>v_g</i> | Sat. liquid, <i>u_f</i> | Evap., <i>u_{fg}</i> | Sat. vapor, <i>u_g</i> | Sat. liquid, <i>h_f</i> | Evap., <i>h_{fg}</i> | Sat. vapor, <i>h_g</i> | Sat. liquid, <i>s_f</i> | Evap., <i>s_{fg}</i> | Sat. vapor, <i>s_g</i> |
| 30 | 69.09 | 0.001022 | 5.2287 | 289.24 | 2178.5 | 2467.7 | 289.27 | 2335.3 | 2624.6 | 0.9441 | 6.8234 | 7.7675 |
| 40 | 75.86 | 0.001026 | 3.9933 | 317.58 | 2158.8 | 2476.3 | 317.62 | 2318.4 | 2636.1 | 1.0261 | 6.6430 | 7.6691 |
| 50 | 81.32 | 0.001030 | 3.2403 | 340.49 | 2142.7 | 2483.2 | 340.54 | 2304.7 | 2645.2 | 1.0912 | 6.5019 | 7.5931 |
| 75 | 91.76 | 0.001037 | 2.2172 | 384.36 | 2111.8 | 2496.1 | 384.44 | 2278.0 | 2662.4 | 1.2132 | 6.2426 | 7.4558 |
| 100 | 99.61 | 0.001043 | 1.6941 | 417.40 | 2088.2 | 2505.6 | 417.51 | 2257.5 | 2675.0 | 1.3028 | 6.0562 | 7.3589 |

Table 4 Superheated water

| <i>T</i> °C | <i>v</i> m ³ /kg | <i>u</i> kJ/kg | <i>h</i> kJ/kg | <i>s</i> kJ/kg·K | <i>T</i> °C | <i>v</i> m ³ /kg | <i>u</i> kJ/kg | <i>h</i> kJ/kg | <i>s</i> kJ/kg·K |
|-------------------------------|--------------------------------|-------------------|-------------------|---------------------|--------------------------------|--------------------------------|-------------------|-------------------|---------------------|
| <i>P</i> = 0.05 MPa (81.32°C) | | | | | <i>P</i> = 3.00 MPa (233.85°C) | | | | |
| Sat. [†] | 3.2403 | 2483.2 | 2645.2 | 7.5931 | Sat. | 0.06667 | 2603.2 | 2803.2 | 6.1856 |
| 50 | | | | | 300 | 0.08118 | 2750.8 | 2994.3 | 6.5412 |
| 100 | 3.4187 | 2511.5 | 2682.4 | 7.6953 | 350 | 0.09056 | 2844.4 | 3116.1 | 6.7450 |
| 150 | 3.8897 | 2585.7 | 2780.2 | 7.9413 | 400 | 0.09938 | 2933.6 | 3231.7 | 6.9235 |
| 200 | 4.3562 | 2660.0 | 2877.8 | 8.1592 | 450 | 0.10789 | 3021.2 | 3344.9 | 7.0856 |
| 250 | 4.8206 | 2735.1 | 2976.2 | 8.3568 | 500 | 0.11620 | 3108.6 | 3457.2 | 7.2359 |