

# 國立成功大學

## 113學年度碩士班招生考試試題

編 號： 118

系 所： 工程科學系

科 目： 熱力學

日 期： 0202

節 次： 第 1 節

備 註： 可使用計算機

※ 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。

第 1 至 5 題為選擇題及繪圖題。

- As Fig. 1, steam enters a nozzle at  $450^\circ\text{C}$  and  $800\text{ kPa}$  with a velocity of  $50\text{ m/s}$ , and leaves at  $350^\circ\text{C}$  and  $200\text{ kPa}$  while losing heat at a rate of  $40\text{ kW}$  ( $\text{kJ/s}$ ). Determine the steam at the nozzle exit: (20%)
  - the velocity ( $V_2$ ,  $\text{m/s}$ ) (a) 522, (b) 584, (c) 603, (d) 634, (e) 678, (f) 695, (g) 725
  - the volume flow rate ( $\dot{m}$ ,  $\text{kg/s}$ ) (a) 77, (b) 88, (c) 99, (d) 110, (e) 121, (f) 132
  - the outlet area ( $A_2$ ,  $\text{m}^2$ ) (a) 0.08, (b) 0.07, (c) 0.06, (d) 0.05, (e) 0.04, (f) 0.03
- As Fig. 2, a piston-cylinder device contains  $50\text{ kg}$  of water at  $300\text{ kPa}$  and  $25^\circ\text{C}$  ( $\nu = 0.001\text{ m}^3/\text{kg}$ ). The cross-sectional area of the piston is  $0.1\text{ m}^2$ . Heat is now transferred to the water, causing part of it to evaporate and expand. When the volume reaches  $0.3\text{ m}^3$ , the piston reaches a linear spring whose spring constant is  $75\text{ kN/m}$ . More heat is transferred to the water until the piston rises  $30\text{ cm}$  more. Determine (20%)
  - the final pressure ( $\text{kPa}$ ) (a) 500, (b) 525, (c) 550, (d) 575, (e) 600, (f) 625, (g) 650
  - The quality of final process (%) (a) 13.0, (b) 14.1, (c) 15.4, (d) 16.7, (e) 19.0, (f) 21.3
  - The work done during this process ( $\text{kJ}$ ) (a) 66, (b) 73, (c) 80, (d) 87, (e) 94, (f) 101
  - Also, show the process on a  $P$ - $v$  diagram.
- As Fig. 3, air is compressed by an adiabatic compressor from  $100\text{ kPa}$  and  $12^\circ\text{C}$  to a pressure of  $800\text{ kPa}$  at a steady rate of  $0.2\text{ kg/s}$ . if the isentropic efficiency of the compressor is  $80\%$ . Determine (20%)
  - the exit temperature of air ( $T_2$ ,  $\text{K}$ ) (a) 550, (b) 570, (c) 590, (d) 610, (e) 630, (f) 650
  - the required power input to the compressor ( $\dot{W}$ ,  $\text{kW}$ ) (a) 52, (b) 54, (c) 56, (d) 58, (e) 60, (f) 62
- As Fig. 4, consider a steam power plant operating on the Rankine cycle. Steam enters the turbine at  $3\text{ MPa}$  and  $350^\circ\text{C}$  and is condensed in the condenser at a pressure of  $75\text{ kPa}$ . If the isentropic efficiency of the turbine is  $90\%$ . (20%)
 

Determine

  - the  $q_{\text{in}}$  of the boiler ( $\text{kJ/kg}$ ) (a) 2729, (b) 2745, (c) 2815, (d) 2869, (e) 2900, (f) 2921
  - the  $q_{\text{out}}$  of the condenser ( $\text{kJ/kg}$ ) (a) 1890, (b) 1910, (c) 1950, (d) 2020, (e) 2050, (f) 2090
  - thermal efficiency of the cycle (%) (a) 19.4, (b) 20.4, (c) 21.4, (d) 22.4, (e) 23.4, (f) 25.4
- As Fig. 5, a thin-walled double-pipe counter-flow heat exchanger is used to cool oil ( $C_p = 2.20\text{ kJ/kg}\cdot^\circ\text{C}$ ) from  $150^\circ\text{C}$  to  $40^\circ\text{C}$  at a rate of  $2\text{ kg/s}$  by water ( $C_p = 4.18\text{ kJ/kg}\cdot^\circ\text{C}$ ) that enters at  $25^\circ\text{C}$  at a rate of  $2.5\text{ kg/s}$ . Determine (20%)
  - the rate of heat transfer in the heat exchanger ( $\text{kW}$ ) (a) 384, (b) 404, (c) 424, (d) 444, (e) 464, (f) 484
  - the exit temperature of water ( $^\circ\text{C}$ ) (a) 60.2, (b) 66.3, (c) 71.4, (d) 76.5, (e) 80.6, (f) 86.

Figures and Tables

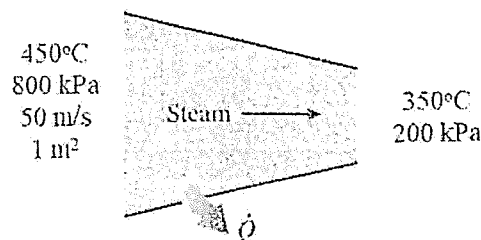


Fig. 1

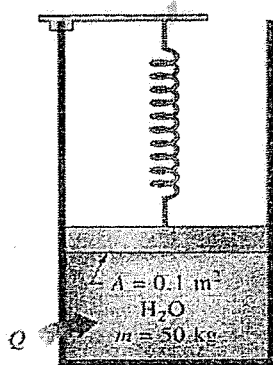


Fig. 2

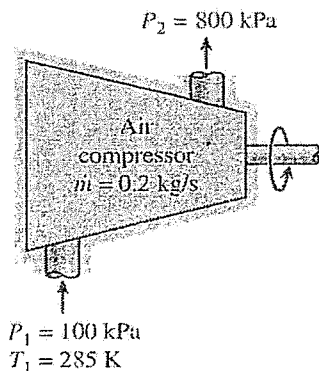


Fig. 3

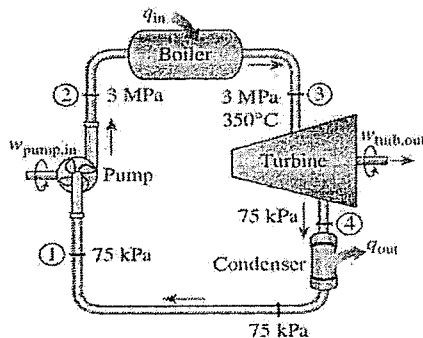
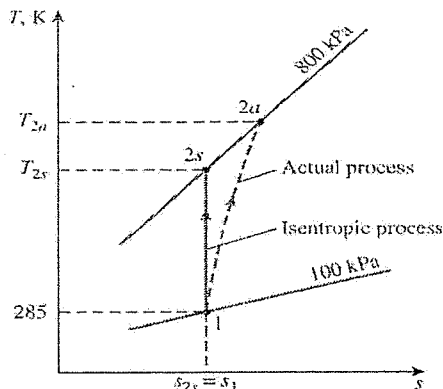


Fig. 4

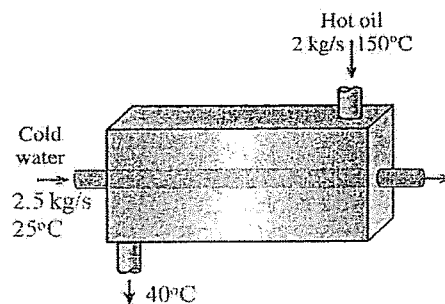
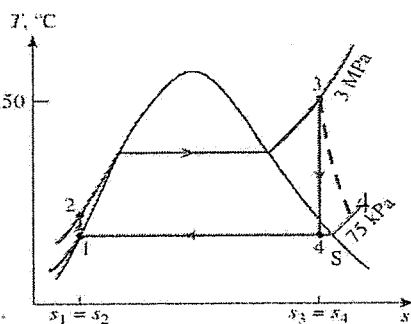


Fig. 5

TABLE A-5

Saturated water—Pressure table

| Press.,<br>P kPa | Specific volume,<br>m <sup>3</sup> /kg |                                |                               | Internal energy,<br>kJ/kg      |                           |                               | Enthalpy,<br>kJ/kg             |                           |                               | Entropy,<br>kJ/kg·K            |                           |                               |
|------------------|--|--------------------------------|-------------------------------|--------------------------------|---------------------------|-------------------------------|--------------------------------|---------------------------|-------------------------------|--------------------------------|---------------------------|-------------------------------|
|                  | Sat. temp.,<br>T <sub>sat</sub> °C     | Sat. liquid,<br>v <sub>f</sub> | Sat. vapor,<br>v <sub>g</sub> | Sat. liquid,<br>u <sub>f</sub> | Evap.,<br>u <sub>fg</sub> | Sat. vapor,<br>u <sub>g</sub> | Sat. liquid,<br>h <sub>f</sub> | Evap.,<br>h <sub>fg</sub> | Sat. vapor,<br>h <sub>g</sub> | Sat. liquid,<br>s <sub>f</sub> | Evap.,<br>s <sub>fg</sub> | Sat. vapor,<br>s <sub>g</sub> |
| 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                        |
| 450              | 147.90                                 | 0.001088                       | 0.41392                       | 622.65                         | 1934.5                    | 2557.1                        | 623.14                         | 2120.3                    | 2743.4                        | 1.8205                         | 5.0356                    | 6.8561                        |
| 500              | 151.83                                 | 0.001093                       | 0.37483                       | 639.54                         | 1921.2                    | 2560.7                        | 640.09                         | 2108.0                    | 2748.1                        | 1.8604                         | 4.9603                    | 6.8207                        |
| 550              | 155.46                                 | 0.001097                       | 0.34261                       | 655.16                         | 1908.8                    | 2563.9                        | 655.77                         | 2096.6                    | 2752.4                        | 1.8970                         | 4.8916                    | 6.7886                        |

TABLE A-6

Superheated water

| T<br>°C                 | v<br>m <sup>3</sup> /kg | u<br>kJ/kg | h<br>kJ/kg | s<br>kJ/kg·K |
|-------------------------|-------------------------|------------|------------|--------------|
| P = 0.20 MPa (120.21°C) |                         |            |            |              |
| Sat.                    | 0.88578                 | 2529.1     | 2706.3     | 7.1270       |
| 300                     | 1.31623                 | 2808.8     | 3072.1     | 7.8941       |
| 400                     | 1.54934                 | 2967.2     | 3277.0     | 8.2236       |
| P = 0.50 MPa (170.41°C) |                         |            |            |              |
| Sat.                    | 0.24035                 | 2576.0     | 2768.3     | 6.6616       |
| 400                     | 0.38429                 | 2960.2     | 3267.7     | 7.5735       |
| 500                     | 0.44332                 | 3126.6     | 3481.3     | 7.8692       |
| P = 3.00 MPa (233.85°C) |                         |            |            |              |
| Sat.                    | 0.06667                 | 2603.2     | 2803.2     | 6.1856       |
| 350                     | 0.09056                 | 2844.4     | 3116.1     | 6.7450       |
| 400                     | 0.09938                 | 2933.6     | 3231.7     | 6.9235       |

TABLE A-17

Ideal-gas properties of air

| T<br>K | h<br>kJ/kg | P <sub>r</sub> | u<br>kJ/kg | v <sub>r</sub> | s <sup>o</sup><br>kJ/kg·K |
|--------|------------|----------------|------------|----------------|---------------------------|
| 280    | 280.13     | 1.0889         | 199.75     | 738.0          | 1.63279                   |
| 285    | 285.14     | 1.1584         | 203.33     | 706.1          | 1.65055                   |
| 510    | 513.32     | 9.031          | 366.92     | 162.1          | 2.23993                   |
| 520    | 523.63     | 9.684          | 374.36     | 154.1          | 2.25997                   |
| 530    | 533.98     | 10.37          | 381.84     | 146.7          | 2.27967                   |
| 550    | 555.74     | 11.86          | 396.86     | 133.1          | 2.31809                   |
| 560    | 565.17     | 12.66          | 404.42     | 127.0          | 2.33685                   |
| 570    | 575.59     | 13.50          | 411.97     | 121.2          | 2.35531                   |