八十五學年度國立台灣工業技術學院研究所碩士班招生考試

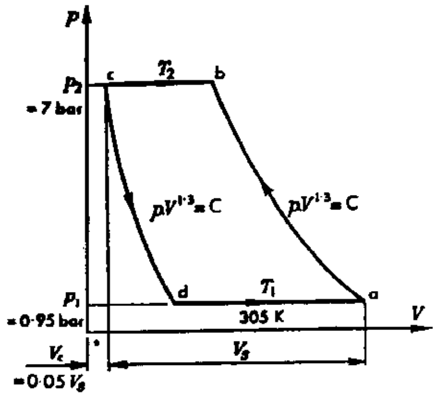
所別：機械工程技術研究所　組別：熱流組　科目：熱力學

1. 30%

A single-stage, double-acting air compressor has a *free air delivery* (F.A.D., the volume delivered, measured at the pressure and temperature of the atmosphere in which the machine is situated) of 14 m^3/min measured at 1.013 bar and 15°C. The pressure and temperature in the cylinder during induction are 0.95 bar and 32°C, respectively. The delivery pressure is 7 bar and the index of compression and expansion, n=1.3. The clearance volume is 5% of the swept volume. The *universal* gas constant is $8314.3\frac{N\cdot m^3}{mole\cdot K}$.

(a) Derive an equation for the **indicated power** in terms of the index of compression and expansion, mass flow rate, gas constant, and temperature difference, then calculate the required indicated power in this case. (20%)

(b) Calculate the **volumetric efficiency** (the volume of air delivered measured at the free air pressure and temperature, divided by the swept volume of the cylinder). (10%)



命題請勿超出線外

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2. 30%

Steam enters a turbine at a pressure of P_i=100 lbf/in^2, a temperature of T_i=500°F, and a velocity of V_i=200 ft/sec. The steam leaves the turbine at a pressure of P_e=20 lbf/in^2 and a velocity of V_e=600 ft/sec. Assume that the process is reversible and adiabatic, <u>determine</u> the **work per pound of steam** flowing through the turbine. Use the following data for calculation:

For steam at P=100 lbf/in^2 and T=500°F the enthalpy and entropy are h=1279.1 Btu/lbm and s=1.7085 Btu/lbm°R.

For steam at P=20 lbf/in^2, s_g=1.7320 Btu/lbm °R, s_{fg}=1.3962 Btu/lbm°R, h_g=1156.4 Btu/lbm, h_{fg}=960.1 Btu/lbm.

g_c=32.174 lbm-ft/lbf-sec^2.

1Btu=778 ft-lbf.

3. 20%

A composite three-layered wall is formed of a 0.5-cm-thick aluminum plate, a 0.25-cm-thick layer of sheet asbestos, and a 2.0-cm-thick layer of rock wool (density = 64 kg/m^3); the asbestos is the center layer. The outer aluminum surface is at 500°C, and the outer rock wool surface is at 50°C. <u>Determine</u> the **heat flow per unit area**. Use the following data of conductivities for calculation:

At 500°C, $k_{aluminum}$= 268.08 W/m-K.

At 50°C, $k_{asbestos}$= 0.1660 W/m-K.

At 93°C, $k_{rock\ wool}$= 0.0548 W/m-K.

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4. 20%

Liquid mercury flows through a 20-mm-i.d. copper tube at the rate of 1 kg/s. The mercury enters at T_i=12°C and is heated to T_o=28°C as it passes through the tube. For a *constant heat flux* at the wall, which is at an average temperature of 40°C, determine the **length of tube** required. Use the following data for calculation:

At the mean bulk temperature, $T_b = \frac{T_i + T_o}{2} = \frac{12+28}{2} = 20\,°C$,

the fluid properties of mercury are

$\rho = 13,580\, kg/m^3$, density.

$c_p = 139.33 J/kg-K$, constant pressure specific heat.

$\nu = 1.143 \times 10^{-7} m^2/s$, kinematic viscosity.

$k = 8.683\ W/m-K$, thermal conductivity.

$\Pr = 0.0249$, Prandtl number.

For constant heat flux at the wall of a tube, with fluid properties evaluated at the mean bulk temperature, the average Nusselt number valid for $3600 < \mathrm{Re}_D < 9.05 \times 10^5$ and $100 < Pe_D < 10^4$ can be calculated by

$\overline{Nu_D} = \frac{\bar{h}D}{k} = 4.82 + 0.0185 Pe_D^{\ 0.827}$, where D is the inner tube diameter, $\bar{h}$ the average convective heat transfer coefficient, and Pe_D the Peclet number.

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