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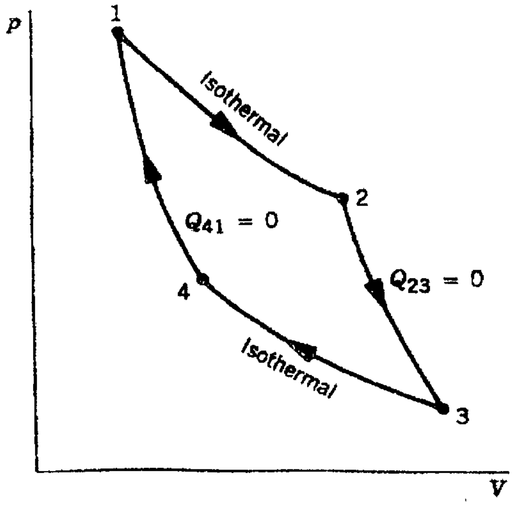
1. Two reversible power cycles are arranged in series. The first cycle receives energy by heat transfer from a reservoir at temperature T_H and rejects energy to a reservoir at an intermediate temperature T. The second cycle receives the energy rejected by the first cycle from the reservoir at temperature T and rejects energy to a reservoir at temperature T_C lower than T. Derive an expression for the intermediate temperature T in terms of T_H and T_C when
   (a) the net work of the two power cycles is equal. (6%)
   (b) the thermal efficiencies of the two power cycles are equal. (6%)

2. The pressure-volume diagram of a Carnot power cycle executed by an ideal gas with constant specific heat ratio k is shown in figure. Demonstrate that $\mathbf{V_4 V_2 = V_1 V_3}$. (12%)



（背面仍有題目.請繼續作答）

編號： 88 系所：機械工程學系甲組 科目：熱力學

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3. Air enters a compressor operating at steady state at 17℃, 1 bar and exits at a pressure of 5 bars. Kinetic and potential energy changes can be ignored. If there are no internal irreversibilities, evaluate the work and heat transfer, each in kJ per kg of air flow, for the following cases:

   (a) isothermal compression. (6%)

   (b) polytropic compression with n = 1.3. (6%)

   (c) adiabatic compression. (6%)

   (d) sketch the processes on P-v and T-s diagrams, and clearly mark each case. (8%)

Ideal Gas Properties of Air

T (K), h and u (kJ/kg), s° (kJ/kg · K)

						T	h	P_r	u	v_r	s°
T	h	p_r	u	v_r	s°	T	h	p_r	u	v_r	s°
200	199.97	0.3363	142.56	1707.	1.29559	450	451.80	5.775	322.62	223.6	2.11161
210	209.97	0.3987	149.69	1512.	1.34444	460	462.02	6.245	329.97	211.4	2.13407
220	219.97	0.4690	156.82	1346.	1.39105	470	472.24	6.742	337.32	200.1	2.15604
230	230.02	0.5477	164.00	1205.	1.43557	480	482.49	7.268	344.70	189.5	2.17760
240	240.02	0.6355	171.13	1084.	1.47824	490	492.74	7.824	352.08	179.7	2.19876
250	250.05	0.7329	178.28	979.	1.51917	500	503.02	8.411	359.49	170.6	2.21952
260	260.09	0.8405	185.45	887.8	1.55848	510	513.32	9.031	366.92	162.1	2.23993
270	270.11	0.9590	192.60	808.0	1.59634	520	523.63	9.684	374.36	154.1	2.25997
280	280.13	1.0889	199.75	738.0	1.63279	530	533.98	10.37	381.84	146.7	2.27967
285	285.14	1.1584	203.33	706.1	1.65055	540	544.35	11.10	389.34	139.7	2.29906
290	290.16	1.2311	206.91	676.1	1.66802	550	554.74	11.86	396.86	133.1	2.31809
295	295.17	1.3068	210.49	647.9	1.68515	560	565.17	12.66	404.42	127.0	2.33685
300	300.19	1.3860	214.07	621.2	1.70203	570	575.59	13.50	411.97	121.2	2.35531
305	305.22	1.4686	217.67	596.0	1.71865	580	586.04	14.38	419.55	115.7	2.37348
310	310.24	1.5546	221.25	572.3	1.73498	590	596.52	15.31	427.15	110.6	2.39140
315	315.27	1.6442	224.85	549.8	1.75106	600	607.02	16.28	434.78	105.8	2.40902
320	320.29	1.7375	228.42	528.6	1.76690	610	617.53	17.30	442.42	101.2	2.42644
325	325.31	1.8345	232.02	508.4	1.78249	620	628.07	18.36	450.09	96.92	2.44356
330	330.34	1.9352	235.61	489.4	1.79783	630	638.63	19.84	457.78	92.84	2.46048
340	340.42	2.149	242.82	454.1	1.82790	640	649.22	20.64	465.50	88.99	2.47716
350	350.49	2.379	250.02	422.2	1.85708	650	659.84	21.86	473.25	85.34	2.49364
360	360.58	2.626	257.24	393.4	1.88543	660	670.47	23.13	481.01	81.89	2.50985
370	370.67	2.892	264.46	367.2	1.91313	670	681.14	24.46	488.81	78.61	2.52589
380	380.77	3.176	271.69	343.4	1.94001	680	691.82	25.85	496.62	75.50	2.54175
390	390.88	3.481	278.93	321.5	1.96633	690	702.52	27.29	504.45	72.56	2.55731
400	400.98	3.806	286.16	301.6	1.99194	700	713.27	28.80	512.33	69.76	2.57277
410	411.12	4.153	293.43	283.3	2.01699	710	724.04	30.38	520.23	67.07	2.58810
420	421.26	4.522	300.69	266.6	2.04142	720	734.82	32.02	528.14	64.53	2.60319
430	431.43	4.915	307.99	251.1	2.06533	730	745.62	33.72	536.07	62.13	2.61803
440	441.61	5.332	315.30	236.8	2.08870	740	756.44	35.50	544.02	59.82	2.63280

4. Consider a gas obeying the equation of state $pV = Z(T,p)RT$, which can be illustrated by reference to Fig. P4. Derive expressions for the volume expansivity β and the isothermal compressibility κ for the gas in terms of T, p, Z, and the first derivatives of Z. For gas states with $p_R < 3$ and $1.3 \le T_R \le 2$, determine the sign of κ. (20 %)

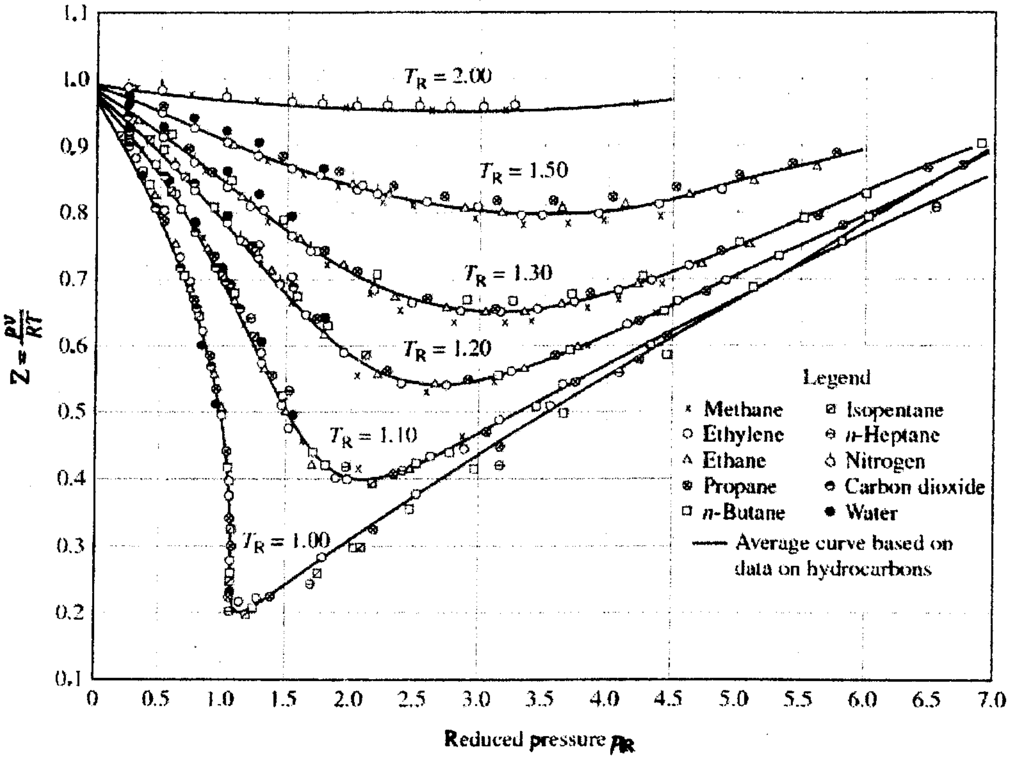

Fig. P4

5. Reducing the compressor work input of a refrigeration system can be accomplished by means of multistage compression. One arrangement of two-stage compression using the refrigerant itself for inter-cooling in a refrigeration system is shown in Fig. P5. A central role is played in the cycle shown in Fig. P5 by a liquid-vapor separator, called a flash chamber. Refrigerant exiting the condenser at state 5 expands through a valve and enters the flash chamber, in which the liquid and vapor components separate into two streams. Saturated vapor exiting the flash chamber enters the heat exchanger at state 9. Saturated liquid exiting the flash chamber at state 7 expands through a second valve into the evaporator. On the basis of a unit mass flowing through the condenser, the fraction of vapor formed in the flash chamber equals the quality x of the refrigerant at

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state 6 for the cycle shown Fig. P5. The fraction of liquid formed is then $(1-x)$. Assume that all the processes in the cycle are internally reversible except for the throttling processes. Plot a *T-s* diagram of the cycle and show the principal states of the refrigerant for the ideal cycle on the *T-s* diagram. (15 %)

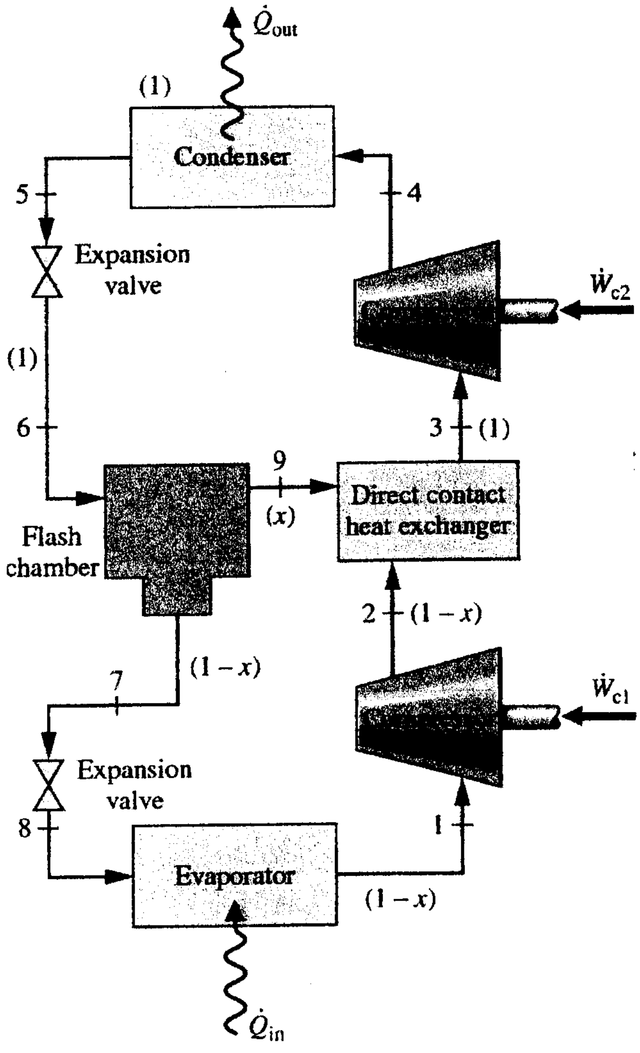

Fig. P5

6. When would the analysis of the mixture in terms of mass fraction be identical to the analysis of the mixture in terms of mole fraction? Explain. (15 %)