(報太沙甲組)

國立成功大學 78 學年度 碩士班考試(熱力學 試題) 共 3 頁 第 1 頁

1. (20%) 在核能電廠運轉時，通常效率約在 40% 左右，約有 60% 的能量未能使用而由冷卻水排出，所以核電廠需要大量的冷卻水，通常冷卻水取用河川或沿海海水，但卻造成河川或沿海的所謂熱污染 (Thermal pollution)，所有問題皆出在因為有 60% 的能量該用而未用(或無法用)，有人建議，把這 60% 的能量用來作功，產生的功，用來趨動一個冷凍機，以便使排放的冷卻水溫度降低，不致造成熱污染，請問 ①這項建議可不可行 ②若可行，該如何運轉(即在何溫度範圍內運轉，自高溫和低溫能庫取多少能量)，③若不可行，請以熱力學定理證明(不是說明)，(若只是說明，最高只給一半分數)，所需答數，請自行以意義清楚即可。

2. (20%) Hydrogen is expanded isentropically in a nozzle from an initial pressure of 100 psia, negligible velocity, to a final pressure of 15 psia. The initial gas temperature is 1000 °R. Assume steady flow with the hydrogen behaving as a perfect gas with constant specific heats, $C_p = 3.4\ Btu/lb_m\,°R$. Determine the final gas velocity and the mass flow through the nozzle for an exit area of two square feet.

3. (20%) The most important sources of power are the chemical energy of fuels. The popular methods for the use of chemical energy are based on the evolution of energy as heat, and subsequent conversion of heat into useful work. However, the work efficiency cannot exceed 40% in general.

   (a) Explain this fact from the thermodynamic point of view; and

   (b) If the conversion system is operated between a maximum temperature of T_1 and a minimum temperature of T_2, what is possibly the maximum work efficiency ?

4. (20%) Determine the minimum work required per Kilogram of air to separate air at 1 atm, 25°C, into nitrogen and oxygen, each at 1atm and 25°C.

(N_2 : $C_p = 1.04\ KJ/kg·°K$, $C_v = 0.743\ KJ/kg·°K$,
O_2 : $C_p = 0.919\ KJ/kg·°K$, $C_v = 0.659\ KJ/kg·°K$,
air = 1 mole of O_2 + 3.76 moles of N_2)

5. A Jet aircraft flies with a velocity of 270 m/sec at an altitude where (20%) the air temperature is −33°C. The inlet and exit areas of the turbojet engine are 0.6 m^2 and 0.4 m^2, respectively. The pressure of the air at the inlet and exit areas of the engine is 50 kpa. The Compressor has a pressure ratio of 9.0, and the inlet temperature to the turbine is 947°C. The pressure increase in the diffuser is 30kpa, and the pressure decrease in the nozzle section is 20kpa. Assume that the engine operates on an ideal cycles and that the power produced by the turbine is just sufficient to operate the compressor. (See Fig. 1 and refer to Table)

(a). Calculate the temperature of the air leaving the Compressor

(b). plot the T-s diagram for the ideal turbojet cycle.

(c). Calculate the inlet temperature to the turbine if the Compressor has a pressure ratio of 14.

(d). Can the jet aircraft fly without the turbine? Explain the reason why.

(e). How to increase the thrust of the jet engine? Explain.

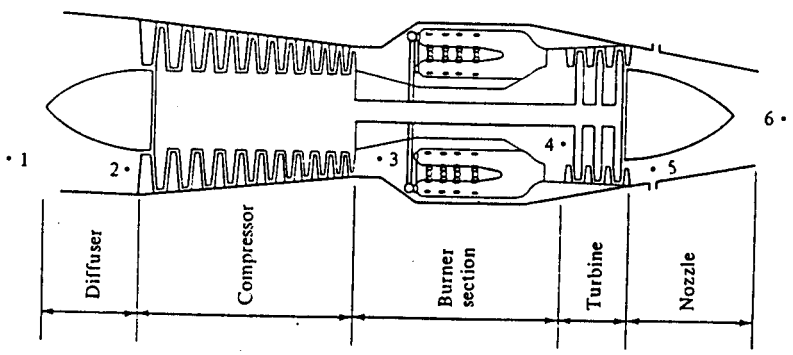

Fig. 1. Components of a simple turbojet engine.

Table IDEAL-GAS PROPERTIES OF AIR (MASS BASIS) (*Continued*)

T, K	h, kJ/kg	u, kJ/kg	s°, kJ/kg·K	P_r	v_r
560	565.17	404.44	7.3367	12.659	29.50
570	575.57	411.98	7.3521	13.500	28.15
580	586.04	419.56	7.3733	14.382	26.89
590	596.53	427.17	7.3912	15.309	25.70
600	607.02	434.80	7.4088	16.278	24.58
610	617.53	442.43	7.4262	17.297	23.51
620	628.07	450.13	7.4434	18.360	22.52
630	638.65	457.83	7.4603	19.475	21.57
640	649.21	465.55	7.4770	20.674	20.784
650	659.84	473.32	7.4934	21.86	19.828
660	670.47	481.06	7.5097	23.13	19.026
670	681.15	488.88	7.5257	24.46	18.266
680	691.82	496.65	7.5416	25.85	17.543
690	702.52	504.51	7.5572	27.29	16.857
700	713.27	512.37	7.5726	28.80	16.205
710	724.01	520.26	7.5879	30.38	15.585
720	734.20	527.72	7.6021	31.92	15.027
730	745.62	536.12	7.6179	33.72	14.434
740	756.44	544.05	7.6326	35.50	13.900
750	767.30	552.05	7.6472	37.35	13.391
760	778.21	560.08	7.6616	39.27	12.905
770	789.10	568.10	7.6759	41.27	12.440
780	800.03	576.15	7.6900	43.35	11.998
790	810.98	584.22	7.7039	45.51	11.575
800	821.94	592.34	7.7177	47.75	11.172
810	832.96	600.46	7.7314	50.08	10.785
820	843.97	608.62	7.7449	52.49	10.416
830	855.01	616.79	7.7583	55.00	10.062
840	866.09	624.97	7.7715	57.60	9.724
850	877.16	633.21	7.7846	60.29	9.400
860	888.28	641.44	7.7976	63.09	9.090
870	899.42	649.70	7.8105	65.98	8.792
880	910.56	658.00	7.8232	68.98	8.507
890	921.75	666.31	7.8358	72.08	8.233
900	932.94	674.63	7.8484	75.29	7.971
910	944.15	682.98	7.8608	78.61	7.718
920	955.38	691.33	7.8730	82.05	7.476
930	966.64	699.73	7.8852	85.60	7.244
940	977.92	708.13	7.8973	89.28	7.020
950	989.22	716.57	7.9092	93.08	6.805
960	1000.53	725.01	7.9211	97.00	6.599
970	1011.88	733.48	7.9328	101.06	6.400
980	1023.25	741.99	7.9445	105.24	6.209
990	1034.63	750.48	7.9560	109.57	6.025
1000	1046.03	759.02	7.9675	114.03	5.847
1020	1068.89	775.67	7.9895	123.12	5.521

Table IDEAL-GAS PROPERTIES OF AIR (MASS BASIS)

T, K	h, kJ/kg	u, kJ/kg	s°, kJ/kg·K	P_r	v_r
1040	1091.85	793.35	8.0124	133.34	5.201
1060	1114.85	810.61	8.0343	143.91	4.911
1080	1137.93	827.94	8.0559	155.15	4.641
1100	1161.07	845.34	8.0771	167.07	4.390
1120	1184.28	862.85	8.0981	179.71	4.156
1140	1207.54	880.37	8.1187	193.07	3.937
1160	1230.90	897.98	8.1390	207.24	3.732
1180	1254.34	915.68	8.1590	222.2	3.541
1200	1277.79	933.40	8.1787	238.0	3.362
1220	1301.33	951.19	8.1982	254.7	3.194
1240	1324.89	969.01	8.2173	272.3	3.037
1260	1348.55	986.92	8.2362	290.8	2.889
1280	1372.25	1004.88	8.2549	310.4	2.750
1300	1395.97	1022.88	8.2733	330.9	2.619
1320	1419.77	1040.93	8.2914	352.5	2.497
1340	1443.61	1059.03	8.3094	375.3	2.381
1360	1467.50	1077.17	8.3271	399.1	2.272
1380	1491.43	1095.36	8.3445	424.2	2.169
1400	1515.41	1113.62	8.3618	450.5	2.072
1420	1539.44	1131.90	8.3788	478.0	1.9808
1440	1563.49	1150.23	8.3957	506.9	1.8942
1460	1587.61	1168.61	8.4123	537.1	1.8124
1480	1611.80	1187.03	8.4287	568.8	1.7350
1500	1635.99	1205.47	8.4450	601.9	1.6617
1520	1660.23	1223.87	8.4610	636.5	1.5925
1540	1684.51	1242.43	8.4769	672.8	1.5263
1560	1708.82	1260.99	8.4926	710.5	1.4640
1580	1733.17	1279.65	8.5081	750.0	1.4047
1600	1757.57	1298.30	8.5234	791.2	1.3485
1620	1782.00	1316.96	8.5386	834.1	1.2951
1640	1806.46	1335.72	8.5536	878.9	1.2442
1660	1830.96	1354.48	8.5685	925.6	1.1959
1680	1855.50	1373.24	8.5832	974.2	1.1499
1700	1880.1	1392.7	8.5977	1025	1.1062
1750	1941.6	1439.8	8.6334	1161	1.0056
1800	2003.3	1487.2	8.6682	1310	0.9164
1850	2065.3	1534.9	8.7021	1475	0.8367
1900	2127.4	1582.6	8.7352	1655	0.7656
1950	2189.7	1630.6	8.7675	1852	0.7021
2000	2252.1	1678.7	8.7992	2068	0.6450
2050	2314.6	1726.8	8.8301	2303	0.5936
2100	2377.4	1775.3	8.8603	2559	0.5474
2150	2440.3	1823.8	8.8899	2837	0.5053
2200	2503.2	1872.4	8.9189	3138	0.4675
2250	2566.4	1921.3	8.9472	3464	0.4331