1. Steam is the working fluid in an ideal Rankine cycle as shown in Fig.1. Saturated vapor enters the turbine at 80.0 bars and saturated liquid exits the condenser at a pressure of 0.08 bar. The net power output of the cycle is 100 MW. The turbine and the pump each have an isentropic efficiency of 85%. The heat exchanger unit of the boiler has a stream of water entering as a liquid at 80.0 bars and exiting as a saturated vapor at 80.0 bars. In a separate stream, gaseous products of combustion cool at a constant pressure of 1 atm from 1107 to 547℃. The gaseous stream can be modeled as air as an ideal gas. Let T_0=22℃, p_0= 1 atm. The condenser involves separate water streams. In one stream a two-phase liquid-vapor mixture enters at 0.08 bar and exits as a saturated liquid at 0.08 bar. In the other stream, cooling water enters at 15℃ and exits at 35℃. Determine for the cycle

(a) the thermal efficiency, (8%)

(b) the mass flow rate of the steam, in kg/h, (8%)

(c) the rate of heat transfer, $\dot{Q}_{in}$, into the working fluid as it passes through the boiler, in MW, (8%)

(d) the rate of heat transfer, $\dot{Q}_{out}$, from the condensing steam as it passes through the condenser, in MW, (8%)

(e) the mass flow rate of the condenser cooling water, in kg/h, (8%)

(f) the net rate at which availability is carried into the heat exchanger unit by the gas stream, in MW, (5%)

(g) the net rate at which availability is carried from the heat exchanger by the water stream, in MW, (5%)

(h) the net rate at which availability is carried from the condenser by the cooling water, in MW, (5%)

(i) the rate at which availability is destroyed, in MW, from the turbine and the pump, (5%)

(j) the irreversibility rate, in MW, of the condenser and the heat exchanger, (5%)

(k) the second law efficiency of the heat exchanger, (5%)

(l) each of the components in the plant the rate at which availability is destroyed, in MW, express each result as a percentage of the availability entering the plant with the fuel. (10%)

($\dot{W}_{pump,isentropic} = V \Delta p$)

2. (a) Describe the Brayton cycle and write down its efficiency in terms of the pressure. (10%)

(b) In order to promote its efficiency, could you propose your suggestion to modify it? (10%)

(背面仍有題目,請繼續作答)

Table 1 Properties of Saturated Water (Liquid-Vapor)

Temp. °C	Press. bars	Specific Volume m³/kg		Internal Energy KJ/kg		Enthalpy KJ/kg		Entropy KJ/kg.K	
		Sat. Liquid $v_f x10^3$	Sat. Vapor v_g	Sat. Liquid $u_f x10^3$	Sat. Vapor u_g	Sat. Liquid $h_f x10^3$	Sat. Vapor h_g	Sat. Liquid $s_f x10^3$	Sat. Vapor s_g
15	0.01705	1.0009	77.926	62.99	2396.1	62.99	2528.9	0.2245	8.7814
35	0.05628	1.0060	25.216	146.67	2423.4	146.68	2565.3	0.5053	8.3531
41.51	0.08	1.0084	18.103	173.87	2432.2	173.88	2577.0	0.5926	8.2287
295.1	80.0	1.3842	0.02352	1305.8	2569.8	1316.6	2758.0	3.2068	5.7432

Table 2 Properties of Compressed Liquid Water

Press. Bars	Enthalpy KJ/kg	Entropy KJ/kg.K
80.0	183.36	0.5957

Table 3 Ideal Gas Properties of Air

T(K), h and u (kJ/kg), s°(kJ/kg.K)			
T	h	u	s°
820	843.98	608.59	2.74504
1380	1491.44	1095.26	3.34474

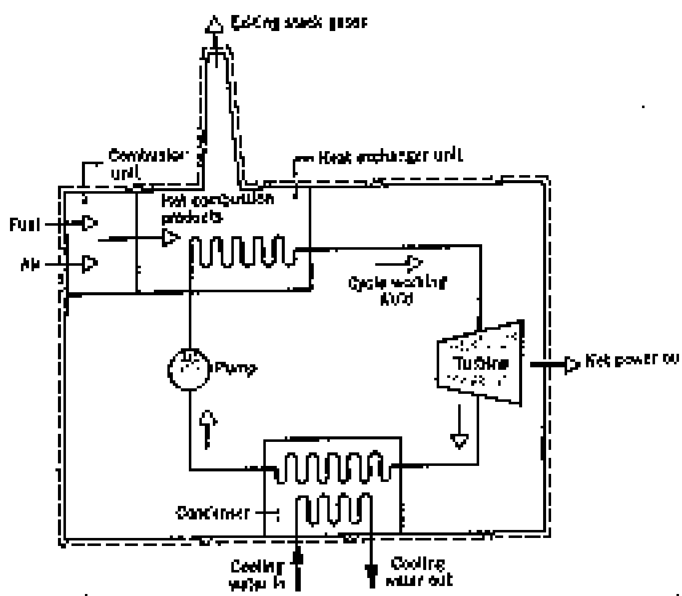

Figure 1. Power plant schematic for the availability analysis case study.