UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	THERMODYNAMICS II
COURSE CODE	:	BDA 30403
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A** : ANSWER **THREE (3)** QUESTIONS **ONLY.** **PART B** : ANSWER **ALL** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

PART A : ANSWER **THREE (3)** QUESTIONS **ONLY.**

Q1 **Figure Q1** shows a steam power plant operating on the Rankine cycle. The plant used to supply power to two generators. Water enters the feed water pump in the saturated state at a pressure of 1.3 bar and out at a pressure of 20 bar. Steam has a maximum temperature of 330°C and expanded in high-pressure turbine to 10 bar before expanded in low-pressure turbine to the condenser pressure is reached. Isentropic efficiency of the high pressure turbine and low pressure are respectively 0.9 and 0.85. If the steam mass flow rate is 400kg/h, determine:

(i) the power of the two turbines;

(ii) the ratio of the plant work;

(iii) the thermal efficiency of the plant;

(iv) the specific steam consumption; and

(v) the power of the two plants where mechanical efficiency is 0.8.

Based on plant layout have been given, draw the above process on a T-s diagram.

(20 marks)

Q2 A gas-turbine engine with regeneration operates with two stages of compression and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 3.5. The air enters each stage of the compressor at 300 K and each stage of the turbine at 1200 K. The compressor and turbine efficiencies are 78 and 86 percent, respectively, and the effectiveness of the regenerator is 72 percent.

(i) Show the cycle on T-s diagram.

(ii) Determine the back work ratio.

(iii) The thermal efficiency of the cycle.

Take, C_p = 1.005 kJ/kgK and k = 1.4.

(20 marks)

Q3 A single-acting compressor is required to deliver air at 80 bar from an induction pressure of 1 bar, at the rate of 3.0 m^3/min measured at free air conditions of 1.013 bar and 20°C. The compression is carried out in two-stages with an ideal intermediate pressure and complete intercooling. The clearance volume is 3 % of the swept volume in each cylinder and the compressor speed is 800 rev/min. The index of compression and re-expansion is 1.3 for both cylinders and the temperature at the end of the induction stroke in each cylinder is 35°C. The mechanical efficiency of the compressor is 85 %. Determine;

(i) the indicated power required;

(ii) the saving in power over single-stage compression between the same pressure;

(iii) the swept volume of each cylinder; and

(iv) the required power output of the drive motor.

(20 marks)

Q4 A two-stage cascade compression refrigeration system is to provide cooling at -40°C while operating the high temperature condenser at 1.6 MPa. Each stage operates on the ideal vapor-compression cycle. The upper vapor compression refrigeration system (VCRS) uses water as its working fluid and operates its evaporator at 5°C. The lower cycle uses refrigerant R-134a as its working fluid and operates its condenser at 400 kPa. This system produces a cooling effect of 20 kJ/s. Determine the mass flow rate of R-134a and water in their respective cycles, and their overall COP of this cascaded system.

(20 marks)

PART B : ANSWER **ALL** QUESTIONS.

Q5 A cooling tower of a small process plant as illustrated in **Figure Q5**, is designed to cool 5.0kg of water per second. The inlet temperature of the warm water is 40°C. The motor-driven fan induces 12 m^3/s of air through the tower and the power absorbed is 6.0 kW. The air entering the tower is at 25°C, and has a relative humidity of 60%. The air leaving the tower is saturated at a temperature of 30°C. The pressure throughout the tower is constant at 101.3 kPa, and the makeup water is added outside the tower.

(i) Calculate the humidity ratio at the air inlet.
(ii) Calculate the amount of the mass flow rate of the makeup water required.
(iii) Determine the final temperature of the water leaving the tower.

(20 marks)

Q6 The compression ratio of an air-standard dual cycle is 12 and a cutoff ratio of 1.3. The pressure ratio during the constant-volume heat addition process is 1.5. This cycle is operated at 100 kPa and 20°C at the beginning of the compression. By using the constant specific heats at room temperature, determine;

(i) the maximum gas pressure;
(ii) the maximum gas temperature;
(iii) amount of heat added; and
(iv) thermal efficiency.

(20 marks)

- END OF QUESTIONS –

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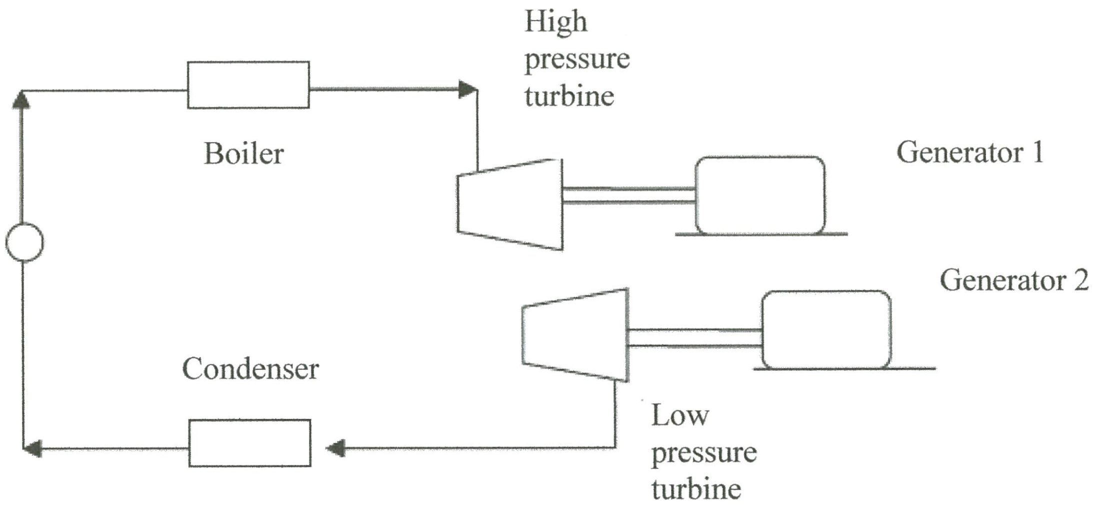

Figure Q1

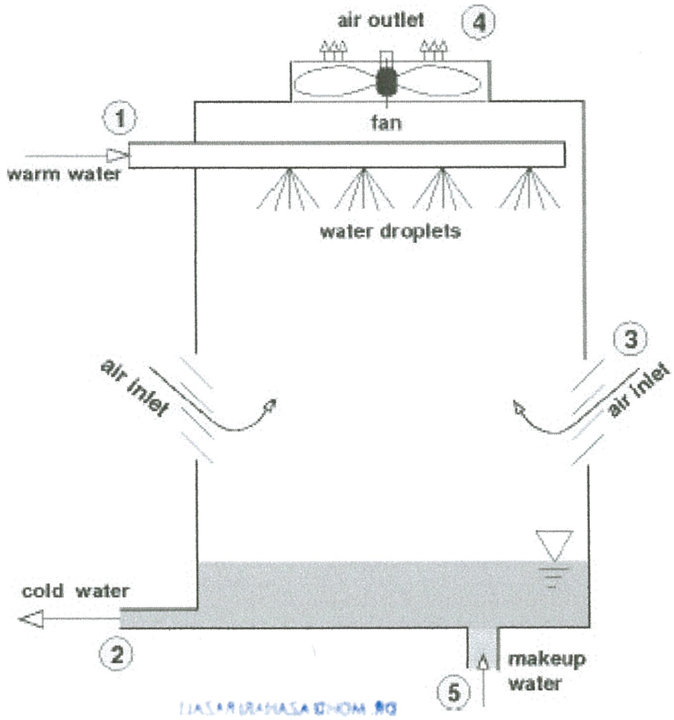

Figure Q5

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Formula

1. *Isentropic relationship and thermal efficiency of Brayton cycle under cold-air-standard assumptions :*

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(k-1)/k} , \qquad \eta_{th,Brayton} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

2. *Compressor work per cycle:*

$$w_{poly} = \frac{n}{n-1} RT_1 \left(\frac{T_2}{T_1} - 1\right) , \quad w_{isen} = \frac{k}{k-1} RT_1 \left(\frac{T_2}{T_1} - 1\right) , \quad w_{iso} = RT_1 \ln \frac{P_2}{P_1}$$

3. *Free Air Delivery (FAD) :* $\text{FAD} = V_a = V_{in} \dfrac{T_a p_1}{T_1 p_a}$

4. *Volumetric efficiency:* $\eta_v = \dfrac{V_{in}}{V_{swept}}$ *or* $\eta_v = 1 - \dfrac{V_c}{V_s}\left(\left(\dfrac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right)$

5. *Indicated Power for z-Stages Compressor :* $\dot{W} = z * \dfrac{n-1}{n} \dot{m} RT_1 \left(\left(\dfrac{P_2}{P_1}\right)^{(n-1)/zn} - 1\right)$

6. *The atmospheric air pressure :* $P = P_a + P_v$

7. *The enthalpy of water vapor in air :* $h_g(T) \cong 2500.9 + 1.82T$ (T in °C)

8. *The enthalpy of dry air :* $h_a = C_p T$

9. *The enthalpy of atmospheric air :* $h = h_a + \omega h_g$

10. *Specific humidity :* $\omega = \dfrac{m_v}{m_a} = 0.622 \dfrac{P_v}{P_a}$ (kg H_2O/ kg dry air)

11. *Relative humidity :* $\phi = \dfrac{m_v}{m_g} = \dfrac{P_v}{P_g}$

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