NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL & MANUFACTURING ENGINEERING

INTRODUCTION TO THERMAL SYSTEMS - TIE 3108

1st SEMESTER EXAMINATIONS FEBRUARY 2010

Time: 3hours
Instructions: Answer ANY FIVE QUESTIONS

SECTION A

QUESTION 1

a) A boiler generates 5000 kg of steam /h at 1.8 MN/m^2 . The steam temperature is 325^0C and the feed water temperature is 49.4^0C . The efficiency of the boiler plant is 80% when using oil of calorific value 45 500 kJ/kg. The steam generated is supplied to a turbine which develops 500 Kw and exhausts at 0.18 MN/m^2 , the dryness fraction of the steam being 0.98. [6]

Estimate

i) the amount of oil used/h and [6]

ii) the fraction of the enthalpy drop through the turbine, which is converted into useful work. [6]

b) What are the maintenance problems associated with boilers? [8]

QUESTION 2

A single stage, double acting compressor has a free air delivery of 14 m^3/min measured at1.013 bar and 15^0C. The temperature and pressure in the cylinder during induction are 0.95 bar and 32^0C. The delivery pressure is 7bar and the index of compression and expansion n=1.3

Calculate

a) the indicated power required and [10]

b) the volumetric efficiency if 5% of the swept volume. [10]

QUESTION 3

Exhaust gases flowing through a tubular heat exchanger at the rate of 0.3 kg/s are cooled from 400^0C to 120^0C by water initially at10^0C. The specific heat of exhaust gases and water may be taken as 1.13 and 4.19 kJ/kgK respectively, and the overall heat transfer coefficient from gas to water is 140 W/m^2 K. Calculate the surface area required when the cooling water flow rate is 4 kg/s for

a) parallel flow . [10]

b) counter flow . [10]

QUESTION 4

a) Identify the three types of heat exchangers and explain their principles of operation [10]

b) Identify the maintenance problems associated with the following plant and Equipment

i) Condenser [2]
ii) Compressor [2]
iii) Cooling tower [2]
iv) Air conditioning plant [4]

QUESTION 5

A small size cooling tower is designed to cool 5.5 litres of water per second the inlet temperature of which is 44^0C. The motor driven fan induces 9 m^3/s of air through the tower and the power absorbed is 4.75kW. The air entering the tower is at 18^0C and has a relative humidity of 60%. The air leaving the tower can be assumed to be saturated and its temperature is 26°C. Assuming that the pressure inside the tower is constant at 1.013bar and makeup water is made outside the tower calculate;

a) The flow rate of make up water required and [10]
b) The final temperature of the water leaving the tower. [10]

Take Pg at 18°C = 0.020 63bar

QUESTION 6

Air is heated by passing it through a 25 mm bore copper tube which is maintained at 280^0C. The air enters at 15^0C and leaves at 270^0C at a mean velocity of 30m/s. Using Reynolds analogy. Calculate:

a) The length of the tube [10]
b) The pumping power required [10]

For turbulent flow in the tube take $f = 0.0791(Re)^{-1/4}$ and all properties at mean film temperature.

QUESTION 7

A combined power plant consists of a gas turbine unit and a steam turbine unit, the exhaust gas from the gas turbine being supplied to the steam generator. Using the data below, neglecting the mass flow rate of fuel, feed pump work, and all pressure losses

Calculate:

a) The cycle efficiency of the gas turbine [5]
b) The cycle efficiency of the steam cycle if the heat supplied in the generator is by external fuel supply. [5]
c) The mass flow rates of air to the gas turbine and steam to the steam turbine [5]
d) The overall efficiency of the combined cycle [5]

Data on the combined steam and gas turbine is shown below

Data:

Pressure ratio for gas turbine, 8

Inlet air temperature to compressor 158˚C

Maximum cycle temperature for gas turbine 8008˚C

Temperature of gases leaving the steam generator 1608˚C

Steam conditions at entry to the turbine, 20 bar and 4008˚C

Condenser pressure, 0.05 bar

Total power output 50 MW,

Isentropic efficiencies of air compressor, gas turbine and steam turbine are 80%, 82% and 80% respectively; c_p and γ for the combustion are 1.11 kJ/kgK and 1.33

End of Exam