BITS, PILANI – DUBAI

Second Semester III Year Mech 2007 – 2008

Comprehensive Exam (Closed book)

(Steam tables and Mollier charts are allowed)

Course No & Title : ME UC314 Power Plant Engineering

Date: 01/06/2008 Time 10.00 AM to 1.00 PM Max: 80 marks

Answer All Questions

1) Briefly discuss the energy balance of a steam generator and write down the expressions for various energy flows into and out of the steam generator

(10MARKS)

2) (a) Draw a graph showing the temperature profiles along the path length in a three zone feed water heater.

(4 MARKS)

(b) A power plant has the following annual factors: Load factor =0.70, Capacity factor = 0.5, Use factor = 0.6: Maximum demand = 20 MW. Estimate the (a) annual energy production, (b) reserve capacity over and above the peak load and (c) the hours per year during which the plant is NOT in service.

(6 MARKS)

3) (a) With neat sketches briefly describe the different types of steam drum separation.

(5 MARKS)

(b) A 10 MW steam turbine operates with steam at 40 bar, 400 C at the inlet and exhausts at 0.1 bar. 10 tons/h of steam at 3 bar are to be taken to a process work. The turbine has 75% isentropic efficiency. Find the boiler capacity required. (5 MARKS)

4) In a combined gas turbine-steam power plant, the exhaust from the open cycle gas turbine is the heat source to the steam generator at which additional fuel is burned to increase the temperature to 750 C of the exhaust gas. The pressure ratio of gas turbine is 7.5 and the cycle maximum temperature is 750 C. The gas leaves the steam generator at 100 C. The steam is generated at 50 bar and at 600 C. The condenser pressure is 0.1 bar and the total power out of the combined plant is 200 MW. Take the calorific value of the fuel as 43.3 MJ/kg. Neglecting the effect of mass flow rate of flue on air flow, determine (a) the flow rates of air and steam required, (b) the power outputs gast turbine and steam turbine, (c) the thermal efficiency of combined power plant and (d) the air-fuel ratio. Take Cp= 1.11 kJ/kgK, γ= 1.33 for combustion gases, and Cp=1.005 kJ/kgK and γ =1.4 for air. Neglect the pump work.

(10MARKS)

5) (a) Briefly discuss with neat diagrams the different types of boiler circulations (5 MARKS)

(b) A fluidized bed combustion system having an output of 35 MW at 80% efficiency when using a coal of heating value 26MJ/kg with a sulphur content of 3.6% requires a particular lime stone to be fed to at a calcium-sulphur ratio of 3, so as to limit emissions of SO_2 adequately. The lime stone contains 85% $CaCo_3$. Determine the required flow rate of lime stone per hour. (5 MARKS)

6) A furnace wall riser, 18 m long, 76.2 mm outer diameter and 6.1 mm thick receives saturated water at 80 bar and 1.50 m/s velocity. Assuming a circulation ratio of 12.5 and slip ratio of 1.2, determine the (a) pressure head developed, (b) void fraction at riser exit and (c) heat transfer rate per unit projected area of the riser tube. (10 MARKS)

7) The velocity of steam entering a simple impulse turbine is 1000 m/s, and the nozzle angle is 20. The mean peripheral velocity of the blades is 400 m/s and the blades are symmetrical. If the steam is to enter the blades without shock, what will be the blade angles?

(i) Neglecting the blade frictional effects, calculate the tangential force, axial thrust, diagram efficiency diagram power for a mass flow of 0.75 kg/s.

(ii) If the relative velocity at the exit is reduced by friction to 80% of that inlet, estimate the axial thrust, diagram power and diagram efficiency. (10 MARKS)

8) (a) Explain the working of LMFBR fast breeder reactor with neat sketches and discuss the effect of breeding ratio 'C' on converter function. (5 MARKS)

(b) A single jet impulse turbine of 10 MW capacity is to work under a head of 500 m. If the specific speed of turbine is 10, the overall efficiency is 80% and the coefficient of velocity is 0.98, find the diameters of the jet and the bucket wheel. Assume the speed of the bucket wheel as 0.46 of the velocity of the jet. (5 MARKS)

OR

9) For a diesel generator, the generator output was 215 A at 210 V, the efficiency of the generator being 85%. The quantity of fuel supplied to the engine was 11.8 kg/h, the calorific value of the fuel being 43 MJ/kg. and the air-fuel ratio was 18 : 1.

The exhaust gases were passed through an exhaust calorimeter with a water circulation of 560 liters/h, temperature rise of water = 38 C, temperature of exhaust gases at exit from calorimeter = 97 C. Specific heat of exhaust gases = 1.04 kJ/kgK and ambient temperature = 30C.

If the heat lost to the jacket cooling water was 32 % of the total energy released by combustion, draw up an energy balance sheet of the engine. (10 MARKS)

Best of Luck!!!

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Second Semester III Year Mech 2007 – 2008

Test II Open Book

Course No & Title : ME UC314 Power Plant Engineering

Date 1/05/2008 Time 50 minutes Max: 40 marks

Answer All Questions

(Text books and reference books on power plant engineering, hand written class notes allowed)

1) Recently many countries celebrated 'Earth Day'. UAE has celebrated on March 29th which was Saturday. During that day it was requested that all the electric power consumption devises to be switched off from 7.00 PM to 8.PM, except emergency and vital equipments. Assume that you are the plant engineer for a power plant that supplies power to the Dubai city. The power plant may run on Coal/CNG/OIL. The power plant may be steam/gas turbine or combined. Assume any one combination of fuel and cycle and discuss the trouble/problem you expect in operating the plant, precaution necessary to keep the plant in sable operating condition. Also discuss whether these kind of shut down for one hour is advisable and will save power/reduce fossil fuel consumption or increase the fuel consumption.

(10MARKS)

2) The velocity of steam leaving the nozzle of an impulse turbine is 900 m/s and the nozzle angle is 20. The turbine rotates at 3000 rpm and has a mean ring diameter of 800 mm. The blade friction factor is 0.7. Calculate for a unit mass flow rate and symmetric blading (a) the blade inlet and outlet angle, (b) the driving force on the wheel, (c) the axial thrust, (d) the diagram power, and (e) the diagram efficiency.

(10MARKS)

3) A 15 m long, 75 mm diameter riser tube receives saturated water at 160 bar and at a velocity of 0.7 m/s. Heat is added to it uniformly. The slip ratio is 1.7. Estimate the maximum heat added to the tube in KJ/m if the exit void fraction is not to exceed 0.80.

(10MARKS)

4) A 1000 MWe power plant is being planned for the rapidly expanding city of Dubai. The plant is expected to operate with a capacity factor of 90%.If the plant is to be of an advanced pulverized coal fired plant with a supercritical water-steam Rankine cycle with 78% efficiency, what is the average daily amount of coal (in kg/day) consumed to power the plant? The imported coal having heating value of 26 MJ/kg, contains 4% sulphur and requires 3 times the mass of calcium to clean the sulphur. It was proposed that limestone available at RAK, which contains 85% CACO3, will be used to clean the sulphur. If you are the plant design engineer, how much limestone you will order per day?

(10MARKS)

Best of Luck!!!

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Second Semester III Year Mech 2007 – 2008

Test I

Course No & Title : ME UC314 Power Plant Engineering

Date : 30/03/2008 Time 50 minutes Max: 50 marks

Answer All Questions

(Steam Tables allowed)

1. Define the term 'Plant Use Factor'. (2 MARKS)
2. What is forced outage rate? (2 MARKS)
3. Why more than two reheats are not used in practice? (2 marks)
4. Write down the Carson and Moses expression for calculating the plume rise height. (2 mark)

5. Derive the expressions for the overall efficiencies of two plants coupled series and parallel and hence show that the overall plant efficiency of a parallel coupled plant is less that of series coupled plant. (6 marks)

6. A power station has a maximum demand of 10000 kW and the daily load on the station is:

6 am to 8 am	3500 kW	5 pm to 7 pm	8500 kW
8 am to 12 noon	8000 kW	7 pm to 9 pm	10000 kW
12 noon to 1 pm	3000 kW	9 pm to 11 pm	4500 kW
1 pm to 5 pm	7500 kW	11 pm to 6 am	2000 kW

   (a) Draw the load curve and the load duration curve.
   (b) Choose the size and number of generating units
   (c) List the operating schedule of the units
   (d) What will be the capacity of reserve plant? Justify your decision.
   (e) Calculate the load factor, Plant capacity factor and plant use factor. (12 marks)

7. Steam at 40 bar, 773 K flowing at the rate of 5500 kg/h expands in a HP turbine to 2 bar with an isentropic efficiency of 83%. A continuous secondary supply of steam at 2 bar , 0.87 quality and a flow rate of 2700 kg/h is mixed adiabatically with the HP turbine exhaust steam and the combined flow expands in a LP turbine to 0.1 bar with an isentropic efficiency of 78%. Determine the power output and thermal efficiency of the plant. Assume that 5500 kg/h of steam is generated in the boiler from the saturated feed water of 0.1 bar pressure. If the secondary supply of steam is not added what would be the power output and thermal efficiency of the plant? Neglect the pump work.

   (14 marks)

8. Coal with composition by weight: Carbon 75%, Hydrogen 5%, Oxygen 5% moisture 8% and ash 7% is burnt with excess air. The resulting flue gas analysis shows CO2 9.09%, O2 10.555 CO nil and the balance nitrogen. Determine the weight of air used per kg of the coal and the percentage of carbon which is not burnt.

   (10MARKS)

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Best of Luck!!!