BITS, PILANI - DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07
Comprehensive Examination

Course No: ME UC314 Course title: Power Plant Engineering
Date: 29.05.07 Duration: 3 hrs
Max Marks: 40 Weightage: 40%

Note: Steam tables are permitted

Q1a. The peak load on a power plant is 60 MW. The loads having maximum demands of 30 MW, 20 MW, 10 MW, and 15 MW are connected to the power plant. Calculate the diversity factor.

[1]

Q1b. Determine the generating cost per unit of 80 MW power station with the following data:
Capital cost= Rs 160×10^7
Annual cost of fuel= Rs 32×10^6
Annual wages and taxes = Rs 36×10^6
Interest and depreciation=10% of capital cost
Annual load factor=45%

[3]

Q2. In a single – heater regenerative cycle the steam enters the turbine at 30 bar, 400 ^{0}C, and the exhaust pressure is 0.1 bar. The feed water heater is a direct contact type which operates at 5 bar. Neglect pump work. Find the (a) net work output and (b) efficiency of the cycle.

[6]

Q3. In an oil fired boiler, the fuel had an analysis by mass: carbon 80%, hydrogen 8%, sulphur 3%, oxygen 2%, remainder incombustible. The analysis of dry flue gas by volume gave: combined CO_2+SO_2 16%, O_2 1%, there being no CO or SO_3. Using combustion equation, calculate (a) mass of air supplied per kg of fuel, and (b) theoretical air required per kg of fuel.

[6]

Q4. In a tubular type air preheater, the hot flue gases enter the tubes at 315 ^{0}C and leave at 175 ^{0}C. The air enters at 25 ^{0}C flows outside the tubes. Assume that flue gases flow at a rate of 15 kg/s and air has mass flow rate of 12 kg/s. The specific heat of flue gases is 1.1 kJ/kgK and the specific heat of air is 1 kJ/kgK. If the overall heat transfer coefficient is 30 W/m^{2}K, calculate the (a) air exit temperature, (b) total surface area of the tubes.

[5]

Q5. Deduce a general expression for the optimum velocity ratio of an impulse turbine with single row wheels, assuming equiangular blades, a nozzle angle α, and a blade friction factor k_b. What is the (a) optimum velocity ratio, and (b) maximum efficiency, if $\alpha=20^0$ and $k_b=0.83$.

[4]

Q6. A surface condenser receives 100 t/h of steam at 40 ^{0}C with 12% moisture. The cooling water enters at 32 ^{0}C and leaves at 38 ^{0}C. The velocity of circulating water is 2 m/s. The condenser tubes are of 25.4 mm od and 1.25 mm thickness. Determine the (a) rate of flow of cooling water, and (b) the number of tubes. The specific heat of water is 4.187 kJ/kgK.

[5]

Q7a. A turbine develops 10 MW under a head of 25 m at 150 rpm. What is the specific speed?

[1]

Q7b. The following data refers to a proposed hydroelectric power plant:
Available head=25 m
Catchment area=400 sq. km.
Rainfall=150 cm/year
Percentage of total rainfall utilized=60%
Penstock efficiency=95%
Turbine efficiency=80%
Generator efficiency=85%
(a) Calculate the power developed. Take 1 year=8760 hours.
(b) Suggest suitable turbines for the plant.

[3]

Q8. A gas turbine plant consists of a compressor and turbine with a regenerator. Air enters the compressor at 1 bar, 20 ^{0}C. The maximum temperature of the cycle is limited to 900 ^{0}C and the maximum pressure is 6. The effectiveness of the regenerator is 0.7. Estimate the (a) power supplied by the plant in kJ/kg of air, (b) heat supplied in kJ/kg of air, and (c) cycle efficiency. Take for air and gases: $c_p=1$ kJ/kgK and $\gamma=1.4$. Neglect the effect of mass flow rate of fuel on the air flow.

[6]

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07

Course No: ME UC314
Date: 29.04.07
Max Marks: 20

Test 2 – Regular –Open Book

Course title: Power Plant Engineering
Duration: 50 Min
Weightage: 20%

Note: Only the Text Book is permitted. Steam tables are allowed

---

Q1(i). A 210 MW power plant has steam condition at boiler outlet as 150 bar, 550 °C and the condenser pressure is 0.1 bar. The steam generator has risers in the furnace wall 43 m high. The boiler operates on natural circulation and it has a circulation ratio of 16. Determine (i) pressure head developed, and (ii) void fraction at the riser exit, if the slip ratio is 1.2. The risers have 60 mm outer diameter and 3 mm thickness.

[4]

Q1(ii) In continuation with Q1 (i), feed water enters the economizer inlet header at a rate of 500 kg/s and at 150 bar, 170 °C and leaves in the saturated liquid state at 150 bar. The economizer consists of tubes of 70 mm outer diameter and 60 mm inner diameter. To restrict the erosion rate by fly ash, the flue gas velocity should not exceed 12 m/s, while the velocity of water leaving the outlet header is 1.2 m/s. Flue gases flow over the economizer coils at a rate of 1200 kg/s and leave the economizer coils at 450 °C. Taking the overall heat transfer coefficient as 70 W/m^2K, estimate the number of coils needed in the economizer and the length of a coil. If the vertical pitch of the coils is 80 mm and the clearance on the two sides of the duct having the width 4.8 m is 5 mm, find the vertical height of economizer. Take C_p of flue gases as 1.12 kJ/kg K.

[6]

Q2. Air flows isentropically from a reservoir at an absolute pressure of 200 kPa and a temperature of 400 K through a nozzle with a throat area of $1cm^2$ and an exit area of 2 cm^2. What will be the maximum flow rate achieved?

[5]

Q3. In a stage of an impulse steam turbine the mean diameter of the blade ring is 500 mm and the speed of rotation is 8000 rpm. The nozzle angle is 20° and steam leaves the nozzle with a velocity of 800 m/s. The blades are equiangular and the blade friction factor is 0.85. Assuming a steam flow rate of 0.2 kg/s, determine (i) diagram power, (ii) diagram efficiency, and (iii) axial thrust.

[5]

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07

B

Course No: ME UC314 | Course title: Power Plant Engineering
Date: 05.04.07 | Quiz 2 - Regular | Duration: 30 Min
Max Marks: 10 | Weightage: 10%
Note: All questions carry equal marks

Name: ID No: Section:

Q1. Coal is taken into the crusher for being broken into the required feed size of _____

a. **300 mm or below**
b. **30 mm or below**
c. **3 mm or below**
d. **0.3 mm or below**

Q2. In _____ mill, coal is pulverized by attrition and impact.

Q3. Sketch the variation of bed pressure drop in the packed and fluidized bed regime with superficial velocity of air

Q4.

1. In fire tube boiler, hot flue gases flow through tubes surrounded by water in the shell.
2. In water tube boiler, water from a drum flows through the tubes and hot flue gases flow over them
3. Fusible plug is used in fire tube boiler
4. Spring loaded safety valve is used in water tube boiler

State which of the above mentioned statements are true?

Q5. The density of nearly saturated water in the downcomer is _____ than the density of two phase mixture in the riser, and this density difference causes _____

Q6. A draught of 25 mm water gauge is required at the base of chimney. The average temperature of gases in the chimney may be taken as 300 °C. the atmosphere is at 30 °C. Assuming the velocity of gases at stack to be negligible, the height of stack is _____. $R_{air}=R_{gas}=0.287$ kJ/kgK, $p_{air}=p_{gas}=101.3$ kPa.

Q7. The required motor capacity needed for FD fan under the following conditions is _____

Fuel burning rate: 10 tonnes/hour, Air fuel ratio: 10 kg air/kg fuel, room temperature: 30 °C, Efficiency of FD fan: 60%, Plenum chamber pressure: 180 mm water gauge, R_{air} =0.287 kJ/kgK, p_{air} =101.3 kPa.

Q8. The required motor capacity needed for ID fan under the following conditions is _____

Fuel burning rate: 10 tonnes/hour, Air fuel ratio: 10 kg air/kg fuel, room temperature: 30 °C, gas temperature: 180 °C, Efficiency of ID fan: 50%, draught produced by ID fan: 250 mm water gauge, $R_{air}=R_{gas}=0.287$ kJ/kgK, $p_{air}=p_{gas}=101.3$ kPa.

Q9. A bed of solid particles has a mass of 2500 kg. The density of solid is 2650 kg/m3. The mean particle size is 1 mm and the sphericity of particles is 0.8. The total surface area of the particles in the bed is _____

Q10. A bed of particles is fluidized by air under ambient conditions. The density of loosely packed bed is 1620 kg/m^3 and the density of solids is 2780 kg/m^3. The voidage of the bed is _____

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07

Course No: ME UC314 — Course title: Power Plant Engineering
Date: 18.03.07 — Test1 – Regular – Closed Book — Duration: 50 Min
Max Marks: 20 — Weightage: 20%

Note: Steam tables are permitted

Q1. The load curve of a power plant is shown in Fig. Q1. Determine load factor?

[2]

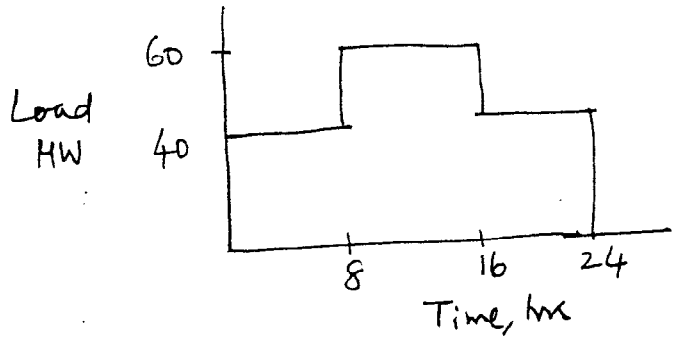

Fig. Q1

Q2. A steam power plant uses the following cycle: steam at boiler outlet: 90 bar and 500 °C, reheat at 18 bar to 500 °C, condensation at 40 °C. Assuming ideal processes, find cycle efficiency? Neglect pump work.

[7]

Q3. The following data refer to a gas turbine power plant.

Air inlet temperature:	**15 °C**
Pressure ratio of compressor :	**8**
Maximum gas temperature at inlet to gas turbine:	**800 °C**
Specific heat of air :	**1.006 kJ/kg K**
Specific heat of gas:	**1.148 kJ/kg K**
Specific heat ratio of air:	**1.4**
Specific heat ratio of gas:	**1.33**

Neglecting the effect of mass flow rate of fuel on air flow, determine the power output per unit mass flow rate of air.

[5]

Q4a. What are lower rank coals? Justify whether the statement "Lower rank coals produce self pulverization of coal particles during combustion" is true?

[2]

Q4b. The ultimate analysis of the fuel oil is given to be: Carbon – 84.7%, Hydrogen – 11.7%, Sulphur – 0.7%, Nitrogen – 1.5%, and Oxygen – 1.4%. Calculate the theoretical air required per kg of fuel.

[4]

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07

A

Course No: ME UC314 | **Course title: Power Plant Engineering**
Date: 01.03.07 | **Quiz 1 - Regular** | **Duration: 30 Min**
Max Marks: 10 | **Weightage: 10%**

Note: All questions carry equal marks

Name: **ID No:** **Section:**

Q1. A power station supplies the following loads to the consumers

Time in hours	0-6	6-16	16-24
Load in MW	30	70	100

The load factor of the plant is _____

Q2. A power station has the maximum annual demand of 25 MW. It supplies loads having maximum demands of 10 MW, 8MW, 6 MW, 4 MW.
The diversity factor is _____

Q3. In a power plant, the efficiencies of the electric generator, turbine, boiler, cycle and overall plant are 0.97, 0.95, 0.92, 0.42 and 0.35 respectively.
The efficiency of auxiliaries is _____

Q4. In a regenerative feed water heating cycle with one feed water heater, m kg of steam is extracted from the turbine for each kg of steam entering to heat feed water from state 5 to state 6, as shown in Fig. Q4.
The mass of steam (m) extracted is expressed as _____

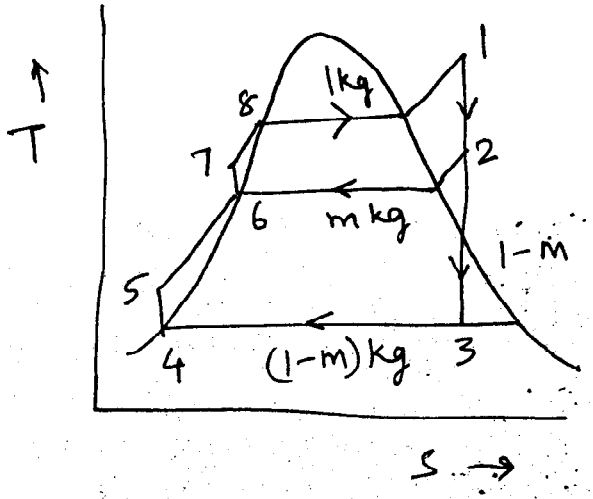

Fig Q4.

Q5. The thermal efficiency of cycle shown in Fig. Q4 is expressed as _____

Q6. In a cogeneration plant, steam is generated at 40 bar and 500 °C and is expanded isentropically through a turbine through a condenser at 0.06 bar as shown in T-s diagram in Fig. Q6. The heating load is supplied by extracting steam from the turbine at 2 bar, which is condensed in the process heater to saturated liquid at 2 bar and then pumped back to the boiler.

The total work output is expressed as _____

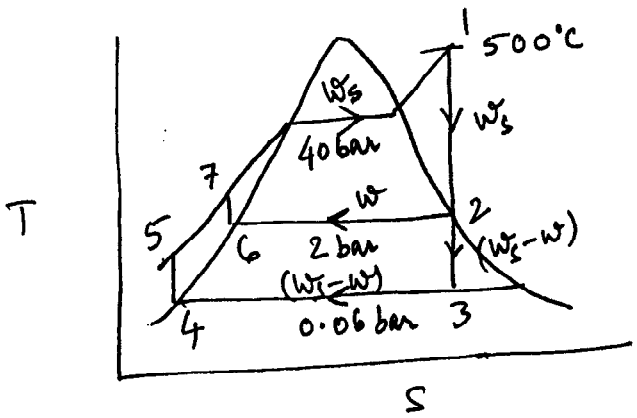

Fig Q6

Q7. With reference to Q6 and Fig. Q6, the heat input to the boiler is expressed as _____

Q8. The mean temperature of heat addition for the Rankine cycle shown in Fig. Q8 is expressed as _____

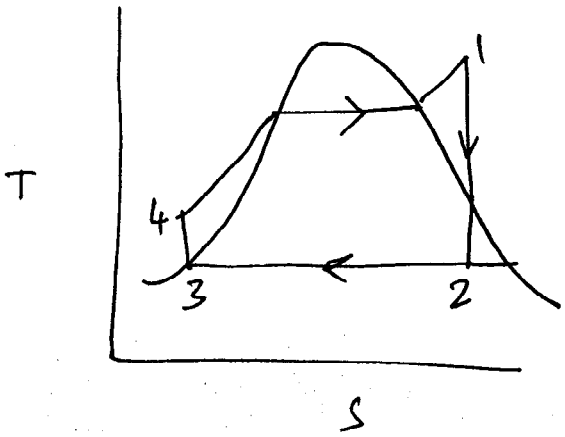

Fig. Q8

Q9. Consider two cyclic power plants coupled in series, the topping plant operating on Brayton cycle and the bottoming one operating on Rankine cycle. If η_1 and η_2 are the thermal efficiencies of the Brayton cycle and the Rankine cycle, respectively,
then the overall efficiency of the combined plant is given by _____

Q10. Consider a practical gas turbine – steam turbine power plant with supplementary combustion of fuel as shown in T-s diagram of Fig. Q10. If w_a being the mass flow of air and w_s is the steam flow rate,
the energy balance is expressed as _____

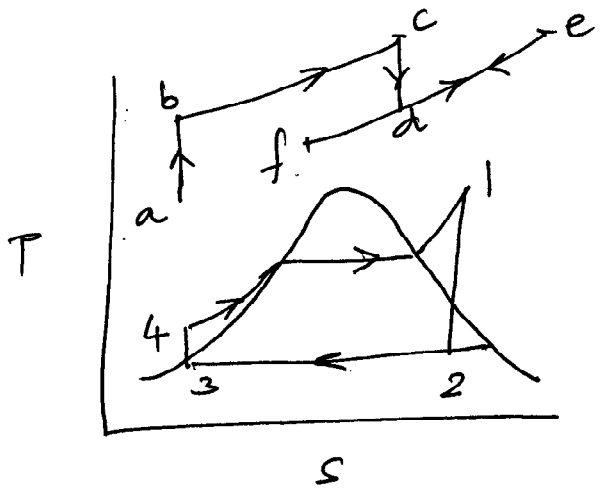

Fig Q10