Code :R7320306

III B.Tech II Semester(R07) Regular & Supplementary Examinations, April/May 2011
THERMAL ENGINEERING-II
(Mechanical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE questions
All questions carry equal marks
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1. (a) Explain with the help of neat diagram a 'Regenerative cycle'. Derive also an expression for its thermal efficiency.
   (b) A sample of fuel on analysis is found to contain carbon 85%, hydrogen 10%, sulphur 2% and ash 3%. Find the higher calorific value of the fuel.

2. (a) Derive an expression connecting the height of a chimney and the draught it produces in terms of atmospheric temperature and mean flue gas temperature.
   (b) To provide a natural draught a chimney of height 16 m is used. Calculate
   (i) the draught in mm of water when the temperature of chimney gases is such that the mass of the gases discharged is maximum,
   (ii) if the temperature of flue gases does not exceed 350^0C, find air supplied per kg of fuel, when discharge is maximum. Take ambient temperature as 20^0C.

3. (a) Explain what is meant by critical pressure ratio of a nozzle.
   (b) Steam at a pressure of 10 bar and 0.9 dry discharges through a nozzle having throat area of 450 mm^2. If the back pressure is 1 bar, find (i) final velocity of the steam and (ii) cross sectional area of the nozzle at exit for maximum discharge.

4. (a) What is the principle of operation of steam turbines?
   (b) The blade speed of a single ring impulse blading is 250 m/s and nozzle angle is 20^0. The heat drop is 550 kJ/kg and nozzle efficiency is 0.85. The blade discharge angle is 30^0 and the machine develops 30 kW, when consuming 360 kg of steam per hour. Draw the velocity diagram and calculate:
   (i) Axial thrust on the blading, and
   (ii) The heat equivalent per kg of steam friction of the blading.

5. A reaction turbine running at 360 R.P.M. Consumes 5 kg of steam per second. Tip leakage is 10%. Discharge blade tip angle for both moving and fixed blades is 20^0. Axial velocity of flow is 0.75 times blade velocity. The power developed by a certain pair is 4.8 KW where the pressure is 2 bar and dryness fraction is 0.95. Find the drum diameter and blades height.

6. (a) Explain: (i) Vaccum efficiency (ii) Condenser efficiency.
   (b) The pressure under the air baffle of a surface condenser is 52 mm of Hg. Temperature of the mixture learing the cooler suction is 25^0C. assuming available water at 15.5^0C, and external water might lower the temperature further to 20^0C. Explain the effect of this on the quantity of vapour accompanying the air to the air pump suction.

7. In a gas turbine plant, the air at 10^0C and 1 bar is compressed to 4 bar with compression efficiency of 80%. The air is heated in the regenerator and the combustion chamber till its temperature is raised to 700^0C, and during the process the pressure falls by 0.14 bar. The air then expanded in the turbine and passes to the regenerator which has 75% effectiveness, and causes a pressure drop of 0.14 bar. If the isentropic efficiency of the turbine is 85%. Determine the thermal efficiency of the plant.

8. A turbo-jet engine consumes air at the rate of 60.2 kg/s when flying at a speed of 1000 km/hr. Calculate:
   (i) Exit velocity of; the jet when the enthalpy change for the nozzle is 230 kj/kg and velocity co efficient is 0.96
   (ii) Fuel flow rate in kg/sec when air fuel ratio is 70:1
   (iii) Thrust specific fuel consumption
   (iv) propulsive power
   (v) Propulsive efficiency
   (vi) overall efficiency.

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Code :R7320306 **2**

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1. (a) Give the advantages and disadvantages of regenerative cycle over simple Rankine cycle.
   (b) The following data were recorded during an experiment to find the calorific value of a sample of coal: Mass of coal burnt 1 gm, mass of water in the calorimeter 1020 gm, water equivalent of the calorimeter 170 gm, initial temperature of water 23.3^0C, final temperature of water 26.2^0C. Determine the calorific value of the sample of the coal.

2. (a) Describe, in brief, the construction of a Locomotive boiler. What is the main disadvantage of the Locomotive boiler?
   (b) In a boiler test 1250 kg of coal are consumed in 24 hours. The mass of water evaporated is 13000 kg and the mean effective pressure is 7 bar. The feed water temperature was 40^0C, heating value of coal is 30000 kJ/kg. The enthalpy of 1 kg of steam at 7 bar is 2570.7 kJ. Determine:
   (i) Equivalent evaporation per kg of coal
   (ii) Efficiency of the boiler.

3. (a) Derive an expression for maximum discharge through convergent-divergent nozzle for steam.
   (b) Dry air at a temperature of 27^0C and pressure of 20 bar enters a nozzle and leaves at a pressure of 4 bar. Find the mass of air discharged, if the area of the nozzle is 200 mm^2.

4. (a) Which type of turbine is used in most of steam turbine power plants? Why?
   (b) In a certain stage of an impulse turbine, the nozzle angle is 20^0 with the plane of the wheel. The mean diameter of the blade ring is 2.8 meters. It develops 55 kW at 2400 r.p.m. Four nozzles, each of 10 mm diameter expand steam isentropically from 15 bar and 250^0C to 0.5 bar. The axial thrust is 3.5 N. Calculate:
   (i) blade angles at entrance and exit and
   (ii) Power lost in blade friction.

5. Derive the condition for maximum efficiency in a parson's reaction turbine.

6. (a) What are the various methods for obtaining maximum vaccum in condensers?
   (b) The air leakage into the condenser operating in conjunction with a steam turbine is estimated at 0.681 kg/min. The vaccum near the outlet to the air pump is 710mm when barometer reads 760 mm of Hg and temperature at this point is 18^0C. Find: (i) The minimum capacity of air pump in m3/min. (ii) Mass of vapour extracted with the air per minute.

7. In a gas turbine plant, the pressure ratio through which air at 15^0C is compressed is 6. The same air is then heated to a maximum permissible temperature of 750^0C first in a heat exchanger which is 75% efficient, and then in the combustion chamber. The same air at 750^0C is expanded in two stages such that expansion work is maximum. The air is reheated to 750^0C after the first stage. Determine the cycle thermal efficiency, the work ratio and shaft work per kg of air. The machine efficiencies may be assumed to be 80% and 85% for the compressor and turbine respectively.

8. For a jet propulsion explain (i) thrust (ii) thrust power (iii) Propulsive efficiency (iv) Thermal efficiency.

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Code :R7320306 **3**

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Answer any FIVE questions
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1. (a) Explain the modified Rankine cycle with p-V and T-s diagrams.
   (b) A bomb calorimeter is used to determine the calorific value of a sample of coal and the following results are obtained: Mass of coal burnt 1 g, mass of water in the calorimeter 2.5 kg, water equivalent of the apparatus 0.75 kg, initial temperature of water 17.5^0C, maximum observed temperature of water 20^0C, cooling correction $+0.015^0$C. If the fuel contains 4% of hydrogen, find the lower calorific value of the fuel.

2. (a) Give the function of the following accessories in a boiler plant
   (i) Economizer (ii) Air pre-heater (iii) Feed pump (iv) Injector (v) Super heater
   (b) Calculate the draught in mm of water column produced by a chimney 30 m high when the average temperature of hot gases is 225^0 C and the temperature of outside air is 20^0 C. The quantity of air supplied is 18 kg / kg of fuel.

3. Draw the 'discharge' versus 'ratio of pressures at outlet to inlet' curve for a convergent steam nozzle. Discuss the physical significance of critical pressure ratio.

4. (a) What is the effect of blade friction on turbine performance?
   (b) Steam issuing from a nozzle at 600 m/s enters the first set of blades of a two row wheel impulse turbine. The tips of both the set of moving blades are inclined at 30^0 to the plane of motion. Find the speed of the blades, so that the steam is finally discharged axially. Neglect friction. Also find the power developed by the turbine, if the mass of steam supplied to the turbine is 3 kg/s.

5. The following data refer to a particular stage of a parson's reaction turbine: Speed of the turbine = 1500 R.P.M. mean diameter of the rotor = 1 metre; stage efficiency: 80%; Blade outlet angle = 20^0, Speed ratio = 0.7. Determine the available isentropic enthalpy drop in the stage.

6. (a) Explain the working principle of an evaporative condenser with a neat sketch.
   (b) A steam jet turbo-generator develops 100 KW using 13.6 Kg of steam per kwhr. The exhaust steam pressure is 0.14 bar and 680.4 Kg of cooling water are passed through the condenser per minute. The inlet and outlet temperatures are 15.6^0C and 32.2^0C respectively. Estimate the dryness fraction of exhaust steam. Temperature of the hotwell is 35^0C.

7. A gas turbine set draws in atmospheric air at 1.013 bar and 15.6^0C, there are two pressure stages with inter cooler, and the total pressure ratio is 8:1. The maximum temperature of the cycle is 593^0C and there is one turbine for expansion. A regenerator is used and recovers 80% of the available heat. Determine the efficiency of the plant and the ratio of useful work to turbine work (i.e., work ratio). The turbine and compressor efficiencies may be taken as 0.86 and 0.83 respectively.

8. Derive the equation for thermal efficiency of a jet nozzle with the help of Brayton cycle for turbo jet engine.

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1. (a) State the comparison between Rankine cycle and Carnot cycle.
   (b) A fuel has the following composition by mass: carbon 86%, hydrogen 11.75%, oxygen 2.25%. Calculate the theoretical air supply per kg of fuel, and the mass of products of combustion per kg of fuel.
2. (a) Establish a condition for maximum discharge of flue gases through chimney.
   (b) Explain briefly about equivalent evaporation of a boiler, induced and forced draught for a boiler.
3. (a) Explain superheated or metastable flow of steam through a nozzle and the significance of Wilson's line.
   (b) The dry and saturated steam at a pressure of 5 bar is expanded isentropically in a nozzle to a pressure of 0.2 bar. Find the velocity of steam leaving the nozzle.
4. Sketch the velocity diagram of a single stage impulse turbine and determine the expressions for the force, work done, diagram efficiency, gross stage efficiency and axial thrust.
5. In a reaction turbine, the fixed blades and moving blades are of the same shape but reversed in direction. The angles of receiving tips are 35^0 and of the discharging tips 20^0. Find the power developed per pair of blades for a steam consumption of 2.5 kg/sec. when the blade speed is 50 m/sec. If the heat drop per pair is 10.04 kj/kg, find the efficiency of the pair.
6. (a) Explain down flow type of surface condenser with a neat sketch.
   (b) The surface condenser is designed to handle 16000 kg of steam per hour The steam enters the condenser at 0.09 bar absolute pressure and 0.88 dryness fraction and the condensate leaves the condenser at the corresponding saturation temperature. Determine the rise in cooling water temperature if the cooling water flow rate is 8.96 x 10^5 Kg/hour. Assume that pressure is constant throughout the condenser.
7. The following data refer to a gas turbine using inter cooling, regeneration, reheating arrangement: Pressure ratio = 4, compressor inlet temperature = 26^0C, Turbine inlet temperature = 600^0C, compressor & Turbine efficiency = 0.8, regenerator effectiveness = 0.85; Inlet pressure to compressor = 1 bar. Determine (i) cycle thermal efficiency (ii) Cycle work ratio (iii) cycle air rate.
8. With the help of a neat diagram, explain the description, advantages, disadvantages of a Turbo-jet engine.

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