Code No: 07A52403 **R07** **Set No. 2**

III B.Tech I Semester Examinations,November 2010
THERMAL ENGINEERING-II
Automobile Engineering

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define the terms:
   i. Heat of formation, and
   ii. Heat of reaction. How are they related?
   (b) When hexane (C_6H_14) is burnt in air, the gas analysis by the Orsats apparatus showed: carbon dioxide = 12%, carbon monoxide = 4% and nitrogen = 84%. What is the excess air factor? [8+8]

2. (a) Define 'degree of reaction' of a reaction turbine? Explain with the help of 'h-s' diagram.
   (b) Describe the constructional features and working principle of operation of a pressure compounding of an impulse turbine.Draw the pressure and velocitiy profiles for a two stage pressure compounded turbine. [4+12]

3. (a) State the components of steam condensing plant and explain the significance of each.
   (b) Steam enters a condenser at 36^0C and with barometer reading 760mm.If the vacuum of 695 mm is produced, finds the vacuum efficiency. [8+8]

4. (a) What are the advantages of Velox boiler?
   (b) Draw the layout of a boiler. What are the considerations in locating super heater, economizer and air pre-heater? [8+8]

5. (a) Why the length of divergent position is larger than the convergent position? Explain.
   (b) Steam at 20 bar, 300^0C enters a convergent-divergent nozzle at the rate of 0.3 kg/s with negligible inlet velocity and expands into a space at 3 bar. Assuming that the steam expands isentropically according to a law $pv^{1.3}$ = constant, estimate the throat and exit areas of the nozzles without using h-s (mollier) chart. [6+10]

6. Find the required air-fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80%, respectively. Maximum cycle temperature is 875^0C. The working fluid can be taken as air (C_p = 1.0 kJ/kg K and γ = 1.4) which enters the compressor at 1 bar and 27^0C. The pressure ratio is 4. The fuel used has calorific value of 42000 kJ/kg. There is loss of 10% of calorific value in the combustion chamber. [16]

7. A simple jet engine has compressor directly coupled to the turbine mounted in an aircraft with forward facing intake and rearward convergent propelling nozzle. Calculate the total thrust when the air craft flies at true air speed of 300 m/s in the ambient total conditions of -10^0 C and 0.58 bar.

   Air mass flow rate : 39 kg/s
   Compressor stagnation pressure ratio : 7.5:1
   Turbine inlet stagnation temperature : 650^0C
   Combustion chamber loss in stagnation : 4%
   Compressor stage efficiency : 82%
   Turbine stage efficiency : 85%
   Combustion efficiency : 100%
   Ram efficiency : 90%
   Nozzle efficiency : 100%
   Mechanical efficiency : 10%
   [16]

8. Twelve successive stages of reaction turbine have blades with effective inlet and outlet angles of 80^0 and 20^0 respectively. The mean diameter of the blade row is 1.2m and the speed or rotation is 3000r.p.m. Assuming constant velocity of flow throughout, estimate the enthalpy drop per stage.
   For a steam inlet condition of 10 bar and 250^0C and the outlet condition of 0.2 bar, estimate the stage efficiency. Assume a reheat factor of 1.04; determine the blade height at a stage where the specific volume is $1.02m^3$/kg. [16]

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Code No: 07A52403 **R07** **Set No. 4**

III B.Tech I Semester Examinations,November 2010
THERMAL ENGINEERING-II
Automobile Engineering

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define a steam condenser and state its objects and explain the types.
   (b) If a barometer stands at 760mm and condenser vacuum is at 710mm and temperature is 30^0C, calculate the mass of air per kg of uncondensed steam. [8+8]

2. Write short notes on the following:
   (a) The furnace gas circuit
   (b) The steam circuit
   (c) Condenser cooling water circuit and
   (d) Cooling air circuit. [4+4+4+4]

3. (a) What do you understand by the terms overexpansion and underexpansion in steam nozzles..
   (b) Steam passes through a convergent divergent nozzle from a pressure of 8 bar. The steam is initially dry saturated. The nozzle efficiency is 90%. Given that the exit area = 2 × throat area, determine the pressure at exit. Assume that the inlet velocity is negligible and n =1.135. . [8+8]

4. (a) Discuss the outstanding features of a locomotive boiler.
   (b) What are the advantages of Benson boiler? [8+8]

5. (a) Derive the expression for efficiency of an impulse turbine.
   (b) A single-row impulse turbine has blades whose inlet angle is 40^0 & and exit angle is 37^0. The mean blade speed is 230 m/s and the nozzles are inclined at an angle of 27^0 to the plane of rotation of the blades. There is a 10 per cent loss of relative velocity due to friction in the blades. The turbine uses 550 kg/h of steam. Determine:
      i. The nozzle velocity of the steam,
      ii. The absolute velocity of the steam at exit,
      iii. The power output of the turbine,
      iv. The end thrust on the turbine and
      v. The diagram efficiency. [4+12]

6. An aircraft has a turbojet engine, flies at a speed of 200 m/s in ambient conditions, 60 kN/m^2 and 260 K. the isentropic efficiency of the intake diffuser is 80 percent. The total head isentropic efficiency of the compressor is 0.82.
The total head pressure of the air, leaving the compressor is 500 kN/m^2
The gases leaving the turbine, at a total head pressure of 175 kN/m^2, and total head temperature of 950 K neglecting mass of the fuel added, find

   (a) total head temperature at turbine inlet,

   (b) the thrust product by a adiabatic, convergent nozzle, which has an exit area 0.16 m^2. take [16]

	Air	Gas
Cp kj/kg k	1.0	1.15
γ	1.4	1.3

7. (a) List the advantages of steam turbines over gas turbines.

   (b) Determine the isentropic enthalpy drop in the stage of Parson's reaction turbine which has the following particulars:
Speed = 1500 rpm
Mean diameter of the rotor = 1 m
Stage efficiency = 80%
Speed ratio = 0.7
Blade outlet angle = 20^0

   [8+8]

8. A 4500 kW gas turbine generating set operates with two compressor stages; the overall pressure ratio is 9:1. A high pressure turbine is used to drive the compressors, and a low- pressure turbine the generator. Temperature of the gases at entry to the high pressure turbine is 625^0C and the gases are reheated to 625^0C after expansion in the first turbine. The exhaust gases leaving the low-pressure turbine are passed through a heat exchanger to heat air leaving the high pressure stage compressor. The compressors have equal pressure ratios and inter cooling is complete between the stages. The air inlet temperature to the unit is 20^0C. The isentropic efficiency of each compressor stage is 0.8, and the isentropic efficiency of each turbine stage is 0.85, the heat exchanger thermal ratio is 0.8. A mechanical efficiency of 95% can be assumed for the both the power shaft and compressor turbine shaft. Neglecting all pressure losses and changes in kinetic energy calculate:

   (a) The thermal efficiency

   (b) Work ratio of the plant.

   (c) The mass flow in kg/s. Neglect the mass of the fuel and assume the following:
For air: C_{pa} = 1.005 kJ/kg K and γ = 1.4.
For gases in the combustion chamber and in turbines and heat exchanger, C_{pg} = 1.15 kJ/kg K and γ = 1.333. [16]

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Code No: 07A52403 **R07** **Set No. 1**

III B.Tech I Semester Examinations,November 2010
THERMAL ENGINEERING-II
Automobile Engineering

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

Answer any FIVE Questions
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1. A gas turbine power plant operates with air entering the compressor at 1 bar and 27^0C, and a pressure ratio of 5 and the turbine inlet temperature of 1000^0C. Calculate the cycle thermal efficiency, the temperature of exhaust gases after heat exchange, assuming the working fluid to be air, with constant specific heat capacity and with heat exchanger, making use of 75 percent of available heat. Assume compressor and the turbine efficiencies to be 80 percent. Neglect the pressure drop in the connecting pipes and the mass of fluid added. Find also overall efficiency without heat exchange. [16]

2. (a) What do you mean by the term 'full admission' of a reaction turbine?
   (b) Describe the constructional features and working principle of a Curtis turbine. Also draw the 'pressure' and 'velocity' profiles for a two stage Curtis turbine. [4+12]

3. (a) Explain clearly the various factors affecting the performance of a propulsion device.
   (b) What is meant by thrust augmentation and explain how it is effected. [8+8]

4. In a reaction turbine the blade tip angles of both fixed and moving blades at inlet and exit are 35^0 and 20^0 respectively. The mean ring diameter of a pair of blades is 1.5 m and the blade height 15 cm. the steam which passes through the pair at the rate of 20 kg/sec is dry and saturated at 2.4 kg/cm^2 abs.
   Find
   (a) Axial velocity
   (b) The blade speed, and Power developed at the speed. [16]

5. (a) Describe the pressure and velocity variations along with the length of a convergent-divergent nozzle as back pressure is reduced.
   (b) Calculate the throat and exit diameters of a convergent-divergent nozzle which will discharge 0.25 kg/s of steam from a pressure of 8 bar, 250 ^{0}C, into a chamber having a pressure of 1.5 bar. Friction loss in the divergent part of the nozzle is taken as 0.15 of the isentropic enthalpy drop. The convergent part is sharp and friction less. Neglect the inlet velocity of steam. [6+10]

6. (a) Differentiate between central flow and downward flow surface condensor.

(b) In a condenser air pump and water pump are separately installed. Steam enters the condenser at 41.5^0C and the condensate is removed at 37.6^0C. The quantity of air infiltrating into the condenser through various zones is 6 kg/h. determine:

i. The volume of air handled by the air pump.

ii. The quantity handled by a combined air and condensate pump at 39^0C. Make suitable assumptions and list all such assumptions. [8+8]

7. (a) What is the effect of decreasing condenser pressure on the efficiency of a Rankine cycle?

(b) Compare Rankine and Carnot cycles, when the condition of steam at the turbine inlet is.

i. Wet state,

ii. Dry state, and

iii. Super heated state. [7+9]

8. (a) What are the advantages of Schmidt-Hartmann boiler?

(b) What is the purpose of air pre-heater? With a neat sketch, explain the working of a tubular air heater. [8+8]

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Code No: 07A52403 **R07** **Set No. 3**

III B.Tech I Semester Examinations,November 2010
THERMAL ENGINEERING-II
Automobile Engineering

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive the expression for work-output of a reaction turbine.
   (b) Steam leaves the nozzles of a single-stage impulse turbine with a velocity of 1000 m/s. The nozzles are inclined at an angle of 24^0 to the direction of motion of the turbine blades. The mean blade speed is 400 m/s and the blade inlet and exit angles are equal. The steam enters the blades without shock and the flow over the blades is considered to be frictionless. Determine:
      i. The inlet angle of the blades,
      ii. The force exerted on the blades in the direction of their motion, and
      iii. The power developed when the steam flow rate is 4000 kg/h. Use graphical method. [4+12]

2. (a) Define the term 'degree of reaction' as applied to a steam turbine. Show that for Parson's reaction turbine the degree of reaction is 50%.
   (b) Prove that the maximum efficiency of a single stage reaction steam turbine is given by the expression.

$$\eta_{\max} = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$$

   Where α = nozzle angle.
   State any assumptions you make and explain when it can be used [8+8]

3. (a) What are the effects of super saturated flow on the performance of nozzle?
   (b) Derive the expressions for maximum velocity and discharge through a convergent-divergent nozzle in terms of initial pressure, specific volume and polytropic index. [6+10]

4. In a gas turbine the compressor takes in air at a temperature of 15^0C and compresses it to four times the initial pressure with an isentropic efficiency of 82%. The air is then passed through a heat exchanger heated by the turbine exhaust before reaching the combustion chamber. In the heat exchanger 78% of the available heat is given to the air. The maximum temperature after constant pressure combustion is 600^0C, and then efficiency of the turbine is 70%. Neglecting all losses except those mentioned, and assuming the working fluid throughout the cycle to have the characteristic of air find the efficiency of the cycle.
   Assume R = 0.287 kJ/kg K and = 1.4 for air and constant specific heats [16]

5. (a) What are the types of solid fuels?

(b) A natural gas has the following composition: methane (CH_2) = 79.8%, ethane (C_2H_6) = 9.23%, propane (C_3H_8) = 4.81%, isobutane (C_4H_10) = 1.06%, n-butane (C_4H_10) = 1.57%, isopentane (C_5H_12) = 0.46%, n-pentane (C_5H_12) = 0.52%, n-hexane (C_6H_14) = 0.04%, moisture (H_2O) = 0.43%, nitrogen (N_2) = 0.79%, and carbon dioxide (CO_2) = 1.29%. It is burnt with 5% excess air. Calculate.

i. The stoichiometric air-fuel ratio, and

ii. The actual air-fuel ratio. [4+12]

6. (a) What is the purpose of air pre-heater? Why air pre-heater is used with only coal burned boiler and not with gas or oil burned boiler? Explain.

(b) What are the difficulties experienced in extracting the maximum heat from the flue gases in economizer? [8+8]

7. A turbo-jet engine travels at 216 m/s in air at 0.78 bar and -7.2^0C. Air first enters diffuser in which it is brought to rest relative to the unit and it is then compressed in a compressor through a pressure ratio of 5.8 and fed in to a turbine at 1110 ^{0}C. The gases expand through the turbine and then through the nozzle to atmospheric pressure (i.e., 0.78 bar). The efficiencies of diffuser, nozzle and compressor are each 90%. The efficiency of turbine is 80%. Pressure drop in the combustion chamber is 0.168 bar. Determine:

(a) Air fuel ratio

(b) Specific thrust of the unit

(c) Total thrust, if the inlet cross-section of diffuser is 0.12 m^3. Assume calorific value of the fuel as 44150 kJ/kg of fuel. [16]

8. Separate air pump and water pump are installed in the condenser. Steam enters the condenser at 40^0C and condensate is removed at 37^0C. The quantity of air infiltrating into the condenser through various zones is 5 kg/hour.

(a) What will be the volume of the air handled by the air pump?

(b) What will be the quantity handled by the combined air and condensate pump at 3^0C? Make suitable assumptions and list all such assumptions. [16]

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