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12MTP22/13MTH22

Second Semester M.Tech. Degree Examination, June/July 2014
Steam and Gas Turbine

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Use of thermodynamic data book is permitted.

1 a. From basic principles, show that for maximum discharge in a steam nozzle, the throat pressure to inlet pressure ratio is given by

$$\frac{P_2}{P_1} = \left[\frac{2}{n+1}\right]^{\frac{n}{n-1}}.$$ **(12 Marks)**

b. An adiabatic steam nozzle is to be designed for a discharge rate of 10kg/s of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take plate in the diverging portion of the nozzle only. Assume a critical pressure ratio of 0.54557. Determine the throat and exit areas. **(08 Marks)**

2 a. Derive the condition of maximum blade efficiency in a single stage impulse turbine and show that $(\eta_b)_{max} = \cos^2 \alpha_1$. **(08 Marks)**

b. The following particulars relate to a two row velocity compounded impulse wheel which forms the first stage of combination turbine:
Steam velocity at nozzle outlet = 650m/s, mean blade velocity = 125m/s, nozzle outlet angle = 16°, outlet angle, first row of moving blades = 18°, outlet angle, fixed guide blades = 22°, outlet angle, second row of moving blades = 36°, steam flow per second = 2.5 kg/s, the ratio of relative velocity at outlet to that at inlet is 0.84 for all blades.
Determine for each row of moving blades the following:
i) The velocity of wheel
ii) The tangential thrust on the blades
iii) The axial thrust on the blades
iv) The power developed
v) The efficiency of wheel as a whole. **(12 Marks)**

3 a. Explain, with the help of neat sketches, the blade profiles and sections for a reaction type steam turbine. **(10 Marks)**

b. The outlet angle of the blade of Parson's turbine is 20° and the axial velocity of flow of steam is 0.5 times the mean blade velocity. Draw the velocity diagram for a stage consisting of one fixed and one moving row of blades, given that the mean diameter is 0.71m and the speed of rotation is 3,000rpm. Calculate the inlet angle of blades if the steam is to enter the blade channels without shock. If the blade height be 0.064m, the mean steam pressure 5.5 bar, the steam dry and saturated (V_s = 0.3427m^3/kg), find the power developed in the stage. **(10 Marks)**

4 a. Explain state point locus of an impulse turbine with h-s diagram. **(08 Marks)**

b. What is reheat factor? Why is it greater than unity? **(04 Marks)**

c. In a four-stage pressure compounded impulse turbine steam is at a pressure of 23bar and superheated to a temperature of 345°C. The exhaust pressure is 0.07 bar and the overall turbine efficiency is 0.72. Assuming that the work is shared equally between the stages and the condition line is straight, estimate the stage pressures, the efficiency of each stage and the reheat factor. **(08 Marks)**

5 a. With a neat velocity triangle diagram, show that work done for an axial flow compressor, $W = uc_a [\tan\beta_1 - \tan\beta_2]$ **(08 Marks)**

b. Briefly explain the surging and stalling in axial compressor. **(08 Marks)**

c. Explain briefly the factors affecting stage pressure ratio. **(04 Marks)**

6 a. Obtain an expression for the specific work output of a gas turbine unit in terms of pressure ratio, isentropic efficiencies of the compressor and turbine, and maximum and minimum temperatures, T_3 and T_1. Hence show that the pressure ratio r_p for maximum power is given by

$$r_p = \left[\eta_C \eta_T \frac{T_3}{T_1}\right]^{\frac{\gamma}{2(\gamma-1)}}.$$ **(10 Marks)**

b. With a neat sketch, explain turbojet engine and derive an expression for thermal efficiency of a turbojet engine. **(10 Marks)**

7 a. Discuss the various methods of cooling gas turbine blades. **(10 Marks)**

b. The following data apply at a given radius to a reaction turbine stage:
Shaft work = 46.5×10^3 J/kg of air, blade velocity = 183m/s, axial velocity of air = 91.5 m/s, stage reaction = 30%. Find inlet and outlet blade angle for shockless entry. **(10 Marks)**

8 a. Write an short notes on the following:
i) Ram jet engine with a neat sketch.
ii) Liquid propellant rocket. With a neat sketch. **(10 Marks)**

b. A turbojet flying at 850 km/h has an air mass flow rate of 50kg/s. The enthalpy drop across the nozzle is 200kJ/kg and the nozzle efficiency is 0.9. The air fuel ratio is 80 and the calorific value of the fuel is 40 MJ/kg. Estimate: i) The propulsive power; ii) Thrust power; iii) Propulsive, thermal and overall efficiency of the unit. **(10 Marks)**

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