MASTER OF POWER ENGINEERING EXAMINATION, 2011

(2nd Semester)

STEAM AND GAS TURBINE

Time : Three hours Full Marks : 100

Answer any ***Five*** questions.

1. a) Deduce a general expression relating area, velocity, pressure etc of a compressible fluid expanding isentropically through a nozzle and draw conclusions regarding the type of nozzle to be used for accelerating flow through the nozzle. 12

   b) What do you mean by choking flow through a nozzle? Give physical explanation for such flow. 8

2. In a 25 kw impulse turbine specific steam consumption is 259.2 kg/kwhr. Steam is expanded in a set of 6 nozzles from 20 bar and 300^0C to 3 bar. What type of nozzle is to be used?

   Determine

   a) Condition of steam at nozzle exit.

   b) minimum diameter of each nozzle.

   c) Mach No at the nozzle exit.

Assume a coefficient of velocity of the nozzles as 0.922. State the assumptions made in solving the problem. 20

3. a) Define degree of admission. Why is partial admission of steam adopted in high pressure stages of an impulse turbine? 6

b) A stage of an impulse turbine is velocity compounded with two rows of moving blades. The isentropic enthalpy drop in the stage is $320\,^{kj}/_{kg}$. The nozzle angle is 16^0 and mean blade speed 150m/sec. Velocity coefficient of the blades is 0.9 for all blades which are symmetrical. Steam flow rate through the turbine is $20\,^{kg}/_{Sec}$. Determine blade angles, power output, stage efficiency and K.E of steam leaving the stage. 14

4. a) Define reheat factor and internal efficiency of a multistage turbine. 4

b) Dry saturated steam at an absolute temperature T_1 expands in a turbine to an absolute temperature T_2. Assuming a very large number of stages, show that the reheat factor is given by

$$R = \frac{T_1 + T_2}{2T_2 + h_s\left(T_1 - T_2\right)}$$

12

Where h_s = stage efficiency of each stage

b) Supersaturated flow through nozzle.

c) Gas Turbine blade cooling.

d) Compounding of steam turbine.

e) Axial thrust in Impulse-reaction turbine

f) Air fuel ratio in a Gas turbine plant.

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mentioned condition is given by :

$$R_{opt} = \left[h_{c.} h_{T.} . \frac{T_{max}}{T_{min}} \right]^{\frac{2}{3} \frac{K}{K-1}}$$

where symbols have their usual meanings. 12

7. a) State the basic requirements of a Gas Turbine Combustion chamber. Describe a Gas Turbine Combustion Chamber with a neat sketch. 8

b) A gas turbine power plant of 12 MW capacity works on closed cycle using air as working medium. The pressure ratio is 4.3, the temperature of air at the inlet of the compressor is 300k and maximum temperature in the cycle is 960k.

Find the cost of energy generated per kwhr using the following data :

Isentropic efficiency of the compressor = 0.8

Isentropic efficiency of the turbine = 0.9

Generator efficiency = 0.96

Combustion efficiency = 0.97

Effectiveness of the regenerator = 0.7

Cost of fuel = Rs 8000 per ton

Calorific value of fuel = 36960 kj/kg

All other charges including profit = Rs. 3000 per hr. 12

8. Write short notes on the following (any ***four***) 4x5

a) Internal losses of steam turbine

c) What is the function of the pressure equalising holes in a Ratean Turbine? 4

5. a) Deduce an expression for the velocity ratio of a parsons turbine corresponding to maximum blade efficiency and show that diagram work per kg of steam flow per sec for maximum blade efficiency is u^2 where u is the mean blade velocity. 8

b) The exit angle of the blades of a Parsons Turbine is 20^0 and the velocity of steam relative to the blade motion at exit is 1.35 times the mean blade speed. The turbine running at 400 rpm. develops 5 MW using 6 kg/kwhr of steam flow. At a particular stage, pressure is 1.2 bar and 0.95 dry. Calculate for this stage (i) a suitable blade height assuming the ratio of mean diameter of the blading to the blade height as 12 and (ii) diagram power. 12

6. a) Why is the back work ratio of gas Turbine plant much higher compared to that of a steam turbine plant? 4

b) What are the advantages of using Helium as working medium instead of air in a closed cycle gas turbine plant? 4

c) A closed cycle gas turbine plant with two stages of compressors with perfect intercooling and a single stage turbine is to be designed for maximum specific work output. Prove that the overall pressure ratio to be used for the above