Ref. No. Ex/PE/T/312/2019

B. E. Power Engineering 3rd Year 1st Semester Examination, 2019

Steam and Gas Turbine

Time: 3 hrs. **Full Marks: 100**

Group-A **Marks: 8 X 2=16**

1. **Answer the following questions briefly (any eight)**

i) Where does shock occur in convergent divergent nozzle?

ii) Write down the relation between the stage efficiency, blade efficiency and nozzle efficiency of a stage of an impulse turbine.

iii) What is the relation between Reheat Factor (RF), internal efficiency (η_n) & stage efficiency (η_s)?

iv) A turbine is designated as 'TC4F30'. Write down the meaning of TC4F30.

v) What is the power output ratio in different rows in 3 row Curtis stage?

vi) What is the reason for compounding of impulse steam turbine?

vii) Write down the names of methods used for improving the performance of a gas turbine plant.

viii) Write down the different losses in steam turbine.

ix) Write down the different blade attachments used in the steam turbine.

x) Write down the different types of rotors used in the steam turbine

Group-B (Answer any one question) **Marks : 10**

2. (a) Explain the 'Frequency Regulation' of turbine governing system.

(b) Describe the principle of operation of the 'Nozzle governing' which is used in Steam Turbine.

(c) What is the function of by-pass governor and emergency governor? Marks: 2+5+3

3. (a) Derive an expression giving relationship between change of cross sectional area of flow with velocity and pressure for a convergent divergent nozzle.

(b) Describe the phenomenon of Supersaturated flow or Metastable flow in Nozzles and explain the effects of supersaturation flow. Marks: 5+5

Group-C **(Answer all questions)** **Marks : 50**

4. Steam at a pressure of 10 bar and 95% dry is supplied through a convergent-divergent nozzle to the wheel chamber, where the pressure is maintained at 0.12 bar. The mass flow rate through the nozzle is 8.16 kg/kW-hr and the work developed by the wheel is 110 kW. 10% of the overall enthalpy drop overcomes friction in the divergent portion resulting in the improved condition of exit steam. Determine i) pressure at the throat, ii) number of nozzles needed if each nozzle has a throat diameter of 5 mm, iii) exit diameter of nozzle.

OR

Steam at 150 bar, 600^0C expands in a steam turbine to 0.1 bar. The blade velocity is limited to 300 m/s and the average nozzle efficiency is expected to be 95%. Nozzle angles will be assumed as 15^0. All stages operate close to the speed of maximum efficiency. Estimate the number of stages required when i) all stages are impulse, ii) all stages are 50% reaction. Marks: 10

5. The isentropic heat drop in a given stage of multistage impulse turbine is 33.5 kJ/kg of steam. The nozzle outlet angle is 20^0. The efficiency of nozzle is 92%. The mean diameter of the blade is 95.5 cm and the revolutions per minute is 3000. The carry over factor is 0.88. Blades are equiangular with a velocity coefficient of 0.87. Calculate i) the steam velocity at the outlet of nozzles, ii) blade angles, and iii) gross stage efficiency.

OR

A velocity compounded impulse turbine has two rows of moving blades with a fixed row of guide blades. The steam leaves the nozzle at 900 m/s in a direction at 18^0 to the plane of rotation. The blade speed is 150 m/s and the blade outlet angles are 24^0, 26^0 and 30^0 for the first moving, first fixed and second moving blade respectively. The friction factor is 0.9 for all rows. The steam supply is 4500 kg per hour. Determine i) Tangential force on the rotor, ii) Total work done on the blades and iii) Power developed by the turbine. Marks:15

6. A 100 MW TG Set is supplied with steam at 90 bar 550^0C and the condenser pressure is 0.1 bar. At rated load the steam supplied is 500 T/hr and at zero load it is 25 T/hr. Boiler efficiency is 90%. Determine i) steam rate in kg/kWh at ¼, ½, ¾ and full load, ii) Rankine efficiency, iii) actual efficiency of plant at full load, iv) turbo generator efficiency at full load based on generator output. Given data: enthalpy of feed water at boiler inlet=192 kJ/kg, enthalpy of steam at boiler outlet = 3511 kJ/kg, isentropic enthalpy of steam at turbine exhaust=2158 kJ/kg. Marks: 10

7. In a gas turbine plant, the air at 283 K and 1 bar is compressed to 4 bar with compression efficiency of 80%. The air is heated in the regenerator and in the combustion chamber till its temperature reached to 973 K and during the process the pressure falls by 0.1 bar. The air is then expanded in 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%, Draw the cycle in T-s diagram and determine the thermal efficiency of the plant.

OR

In the closed cycle gas turbine the following data apply:

a.	Ambient temperature	=	27^0C
b.	Top temperature	=	823^0C
c.	Pressure at compressor inlet	=	1 bar
d.	Pressure ratio	=	4
e.	Compressor efficiency	=	80%
f.	Turbine efficiency	=	85%
g.	Heating value of fuel	=	41800 kJ/kg
h.	Heater loss	=	10% of heating value

i. Assume air as working substance, c_p=1 kJ/kg K, γ=1.4

Find the following: (a) Work ratio, (b) Thermal efficiency, (c) Air rate, (d) Air-fuel ratio, (e) Specific fuel consumption.

Marks: 15

Group-D (Answer any two questions) **Marks 2 X 7=14**

8. Prove that Optimum pressure ratio for maximum specific output considering the turbine & compressor efficiency can be expressed as $R_{p(Optimum)} = \left\{\eta_T \eta_C \frac{T_3}{T_1}\right\}^{\frac{\gamma}{2(\gamma-1)}}$, where, T_3, T_1= Turbine inlet & Compressor inlet temp respectively, η_T, η_C= Turbine & Compressor efficiency.

9. Show that the diagram work per unit mass of steam for maximum blading efficiency of a 50% reaction stage is V_b^2, where V_b is the mean blade velocity of turbine .

10. Prove that the maximum blading or diagram efficiency of Impulse turbine is $\cos^2\alpha$, assuming blade friction factor (k_b) =1, where α is the nozzle angle.

Group-E(Answer any one question) **Marks: 1 X 10=10**

11. (a) Where are the twisted blades used in steam turbine?

(b) What are the reasons for using these twisted blades?

(c) Draw velocity diagram at root and tip of the blade.

(d) Describe the pressure survey method briefly to check the healthiness of steam turbine.

Marks: 1+3+3+3

12. (a) Write down the main basic design features of combustor used in gas turbine plant.

(b) Explain the problems encountered in high temperature operation of gas turbine

(c)Discuss briefly the different cooling methods are employed for cooling the gas turbine blades.

Marks: 4+3+3